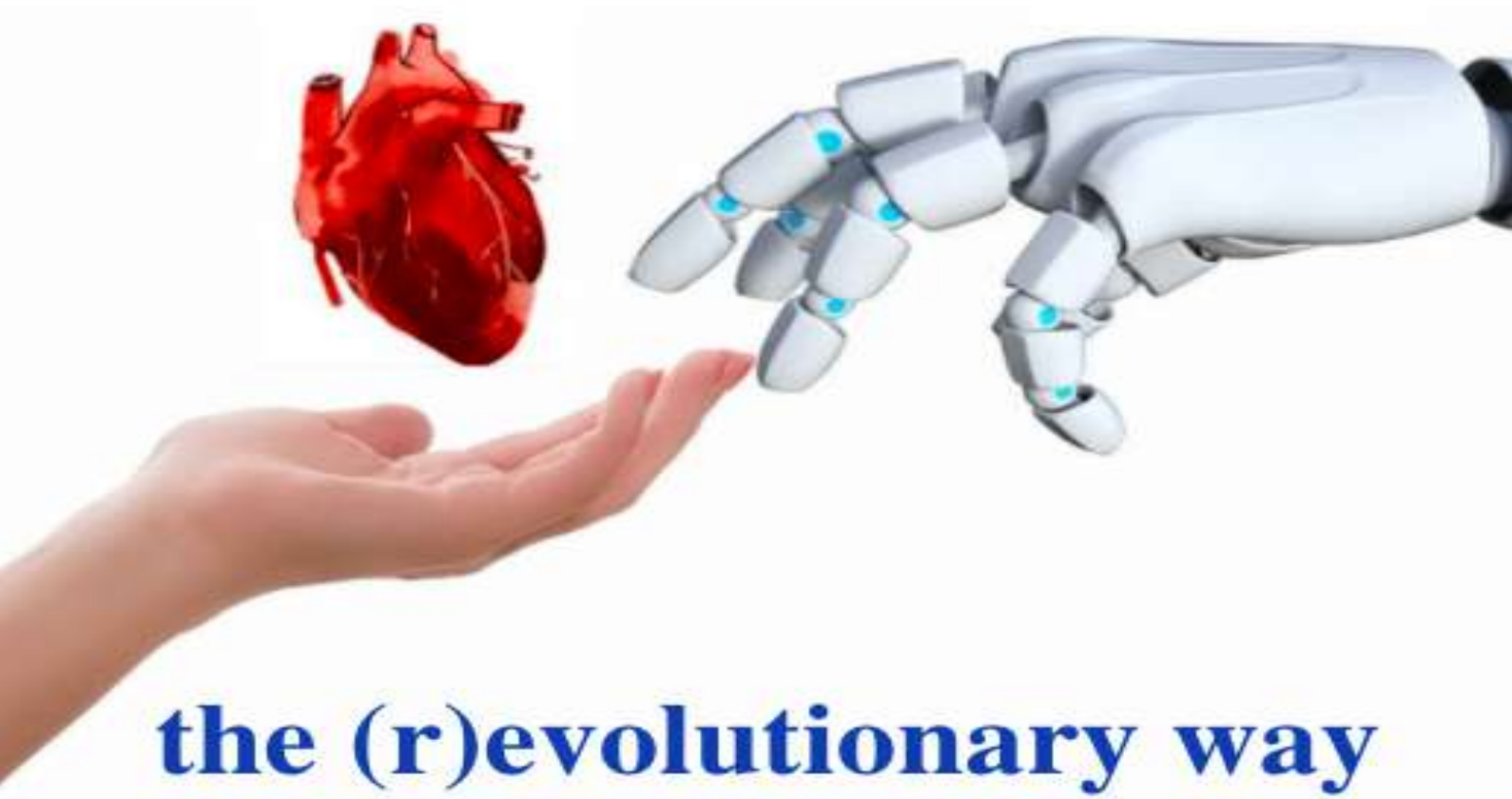
Artificial Intelligence:



the (r)evolutionary way to transform medicine

Course: 2n Batxillerat
"School"
Tutors: Mr. "M"
Dr. A.V., Ph.D

Hippocrates

RESUM

El meu propòsit en aquest treball de recerca és demostrar que les tecnologies emergents, concretament, la intel·ligència artificial (IA), poden ser de gran utilitat per diagnosticar determinades malalties que tenen una gran afectació a nivell mundial com ho és el càncer.

En primer lloc, s'explica en què consisteix la intel·ligència artificial, amb un marc teòric que contempla els seus orígens i evolució, els riscos, els beneficis, l'impacte en la vida humana, l'ètica que presenta per situar-nos en la legislació vigent així com les tècniques més habituals d'IA amb l'aplicabilitat d'aquests mètodes en l'àmbit de la medicina.

En segon lloc, s'exposa la fusió de la intel·ligència artificial amb la medicina des d'un marc teòric que mostra el paper de la IA en diferents àrees mèdiques com ho són la monitorització de pacients, els tractaments personalitzats així com els riscos de hackeig i privacitat que presenten.

La part pràctica del projecte consisteix en el desenvolupament d'un algoritme, basat en *machine learning*, capaç de pronosticar el càncer de mama a partir de les dades recollides i que, d'aquesta manera, l'algoritme pugui detectar si realment el pacient té càncer de mama. Les dades amb les quals s'ha basat el programa han sigut extretes del repositori de dades de *machine learning* de la UCI. Amb aquesta informació s'ha pogut dissenyar un algoritme que detecta amb un 95% de fiabilitat el càncer de mama als pacients. A través dels resultats obtinguts, s'arriba a la conclusió que un diagnòstic precoç és fonamental per a la curació d'un càncer.

Cal mencionar també que d'una manera inesperada però molt gratificant, he estat invitada a la Universitat Rovira i Virgili per tal fer un altre algoritme que ha consistit en predir si el tractament d'immunoteràpia pot ser eficaç contra les berrugues en determinats pacients. Aquest però, no ha assolit tants bons resultats ja que s'ha produït un cas d'*Imbalanced Data*; és a dir s'ha obtingut una desproporció en els resultats presentats ja que han aparegut molts pacients

que han respost correctament al tractament d'immunoteràpia; en canvi, només uns pocs no ho han fet. D'aquesta manera, es pot afirmar que el programa no ha estat entrenat de la mateixa manera per a una situació que per a l'altra i, en conseqüència, ha predit millor la situació per la qual ha estat més entrenat.

Tot això ens fa arribar a la conclusió que un sistema d'IA ha d'estar entrenat proporcionalment als resultats que hi puguin haver per tal d'emetre una diagnosi fiable i prometedora.

Intel·ligència Artificial
Medicina
Càncer de mama

RESUMEN

Mi propósito en este trabajo de investigación es demostrar que las tecnologías emergentes, en concreto, la inteligencia artificial (IA), pueden ser de gran utilidad en el diagnóstico de ciertas enfermedades de gran impacto mundial, como el cáncer.

En primer lugar, se explica en qué consiste la inteligencia artificial, con un marco teórico que abarca sus orígenes y evolución, los riesgos, los beneficios, el impacto en la vida humana, la ética que presenta para situarnos en la legislación vigente, así como las técnicas de AI más comunes con la aplicabilidad de estos métodos en el campo de la medicina.

En segundo lugar, se expone la fusión de la inteligencia artificial con la medicina desde un marco teórico mostrando el papel de la IA en diferentes áreas médicas como la monitorización de pacientes, los tratamientos personalizados y los riesgos de hackeo y privacidad que presenta.

La parte práctica del proyecto es el desarrollo de un algoritmo, basado en el aprendizaje automático, capaz de predecir el cáncer de mama a partir de los datos recogidos y que, de esta forma, el algoritmo pueda detectar si el paciente tiene realmente cáncer de mama. Los datos en los que se ha basado el programa

han sido extraídos del repositorio de datos de aprendizaje automático de la UCI. Con esta información se ha diseñado un algoritmo que detecta con un 95% de fiabilidad el cáncer de mama a los pacientes. Los resultados obtenidos permiten concluir que el diagnóstico precoz es fundamental para la curación del cáncer.

También hay que mencionar que de forma inesperada pero muy gratificante, he sido invitada a la Universidad Rovira y Virgili para realizar otro algoritmo que consiste en predecir si el tratamiento de inmunoterapia puede ser efectivo contra las verrugas en determinados pacientes. Sin embargo, este no ha conseguido tan buenos resultados debido al desequilibrio de los datos; es decir, los resultados son desproporcionados ya que muchos pacientes han respondido correctamente al tratamiento de inmunoterapia; sin embargo, sólo unos pocos no lo han hecho. Por lo tanto, se puede decir que el programa no ha sido entrenado de la misma manera para una situación que para la otra, y por lo tanto ha predicho mejor la situación para la que ha sido más entrenado.

Todo esto nos lleva a la conclusión de que un sistema de IA debe ser entrenado proporcionalmente a los resultados que puedan existir para emitir un diagnóstico fiable y prometedor.

Inteligencia Artificial
Medicina
Cáncer de mama

ABSTRACT

My purpose in this research work is to demonstrate that emerging technologies, specifically artificial intelligence (AI), can be of great use in the diagnosis of certain diseases of great global impact, such as cancer.

Firstly, it explains what artificial intelligence is, with a theoretical framework that covers its origins and evolution, risks, benefits, impact on human life, the ethics it presents to situate us in the current legislation, as well as the most common AI techniques with the applicability of these methods in the field of medicine.

Secondly, the fusion of artificial intelligence with medicine is exposed from a theoretical framework showing the role of AI in different medical areas such as patient monitoring, personalized treatments and the risks of hacking and privacy it presents.

The practical part of the project is the development of an algorithm, based on machine learning, capable of predicting breast cancer from the data collected and that, in this way, the algorithm can detect if the patient really has breast cancer. The data on which the program has been extracted from the UCI's machine learning data repository. With this information, an algorithm has been designed that detects breast cancer in patients with 95% reliability. The results obtained allow us to conclude that early diagnosis is fundamental for the cure of cancer.

It should also be mentioned that unexpectedly but very gratifyingly, I have been invited to the Rovira y Virgili University to perform another algorithm that consists in predicting whether immunotherapy treatment can be effective against warts in certain patients. However, this one has not achieved such good results due to Imbalanced Data; in other words, the results are disproportionate since many patients have responded correctly to the immunotherapy treatment; however, only a few have not. Thus, it can be said that the program has not been trained in the same way for one situation as for the other, and therefore has better predicted the situation for which it has been trained more.

All this leads us to the conclusion that an AI system must be trained proportionally to the results that may exist in order to provide a reliable and promising diagnosis.

Artificial Intelligence
Medicine
Breast Cancer

ZUSAMMENFASSUNG

Mit dieser Forschungsarbeit möchte ich aufzeigen, dass neue Technologien, insbesondere künstliche Intelligenz (KI), bei der Diagnose bestimmter weltweit vorkommender Krankheiten wie Krebs von großem Nutzen sein können.

Zuerst wird erläutert, worauf künstliche Intelligenz (KI) beruht. Dabei werden ihr Ursprung, ihre Entwicklung, die Risiken, Vorteile und der Einfluss auf das menschliche Leben theoretisch umrahmt. Des Weiteren wird die Ethik, die sich an die bestehenden Rechtsvorschriften lehnt, die üblichen Techniken der KI und die Anwendung dieser Methoden im medizinischen Bereich beleuchtet.

Darüber hinaus wird die Verschmelzung von künstlicher Intelligenz und Medizin theoretisch aufgearbeitet, wobei die Rolle der KI in den verschiedenen Bereichen der Medizin, wie beispielsweise in der Patientenüberwachung, den personalisierten Behandlungen und die durch sie hervorgekommene n Risiken von Hacking und der Privatsphäre veranschaulicht werden.

Der praktische Teil des Projekts besteht aus der Entwicklung eines auf *machine learning* basierten Algorithmus, der in der Lage ist, Brustkrebs anhand von gesammelten Daten vorherzusagen. Auf diese Weise kann er erkennen, ob die Patientin tatsächlich Brustkrebs hat. Die Daten, auf welchen das Programm basiert, stammen aus dem Datenspeicher für maschinelles Lernen der UCI. Mit diesem Datenbestand konnte ein Algorithmus entwickelt werden, der mit 95-prozentiger Sicherheit Brustkrebs bei Patientinnen erkennt. Mithilfe der gewonnenen Ergebnisse kann festgestellt werden, dass eine frühzeitige Diagnose für die Heilung von Krebs grundlegend ist.

Zudem sollte angeführt werden, dass ich zwar unerwartet, jedoch erfreulicherweise an die Universität Rovira i Virgili eingeladen wurde, um einen anderen Algorithmus zu entwickeln. Dieser sollte voraussagen, ob eine Immuntherapie gegen Warzen bei bestimmten Patienten wirksam sein könnte. Da es sich hierbei um einen Fall von *Imbalanced Data* handelte, hat dieser allerdings nicht so gute Ergebnisse erzielt. *Imbalanced Data* bedeutet, dass in den vorgelegten Ergebnissen ein Missverhältnis vorherrscht, in diesem Fall aus dem Grund, dass viele Patienten auf die Immuntherapie korrekt angesprochen haben, hingegen nur wenige nicht. So kann bestätigt werden, dass das Programm nicht auf dieselbe Weise auf die neue Situation eingestellt wurde wie auf die vorige und folglich die, auf die es besser eingestellt war, auch besser vorhergesagt hat.

All diese Aspekte führen zu der Schlussfolgerung, dass ein KI-System proportional zu seinen möglichen Ergebnissen eingestellt werden muss, um eine zuverlässige und vielversprechende Diagnose zu liefern.

Künstliche Intelligenz
Medizin
Brustkrebs

RESUM DE TOT EL TREBALL EN ANGLÈS

1. Introducció

El meu treball de recerca se centra en la manera en què la intel·ligència artificial revolucionarà la medicina.

La meva investigació se centra en introduir una tecnologia eficaç amb un marge mínim d'error, com la IA, per millorar la medicina actual evitant diagnòstics erronis i males pràctiques, oferint així el regal més valuós als metges: el temps.

L'elecció del tema d'aquest treball es basa en la meva ídol. Ella Kavya Kopparapu, una jove informàtica que ha desenvolupat programari que utilitza l'aprenentatge profund per determinar les signatures moleculars i genètiques del tumor cerebral. No obstant això, el seu mètode es pot aconseguir en una fracció del temps i el cost dels mètodes tradicionals! Increïble, oi?

A més, és la fundadora de Girls Computing League, una organització sense ànim de lucre dedicada a fer accessible l'educació tecnològica emergent a tots els estudiants.

Així que, tan aviat com vaig acabar de llegir tot sobre Kavya Kopparapu, vaig pensar que era un clar exemple a seguir, i així és com el poder de la intel·ligència artificial va arribar a les meves mans.

El poder de la IA implica moltes àrees; malgrat això, he decidit centrar-me en el camp de la medicina en aquest projecte. A través d'aquest treball de recerca, podran apreciar que la IA pot promoure la nostra salut, prevenir malalties, detectar-les més ràpid, i fins i tot ser un regal de temps!

Estic emocionada pel futur; pel poder de la IA i per totes les dades recopilades. No queden dècades; aquesta revolució està portant al món a la quarta revolució industrial. Entrem!

2. Metodologia

Per a desenvolupar aquest projecte, ha estat necessària una metodologia. Per això, en primer lloc, havia de descobrir més sobre els conceptes essencials com el terme Intel·ligència Artificial (IA), les tècniques que impliquen amb si mateixes, el sistema sanitari occidental, entre altres.

Per fer recerca literària, he llegit llibres, articles científics de revistes indexades d'impacte internacional i pàgines web de divulgació científica per abordar el tema amb la màxima evidència.

Per tant, he intentat fusionar el terme medicina amb la IA per a poder entendre la importància que la IA suggereix en el sistema sanitari sobre el seu impacte en el camp del diagnòstic, el seguiment del pacient i fins i tot en el desenvolupament de medicaments personalitzats.

Per dur a terme la meva part pràctica, m'he centrat en l'aprenentatge automàtic, una de les tècniques de IA que explicaré amb més detall en algunes diapositives més. Concretament, he après més sobre l'algorisme KNN que m'ha permès aplicar la IA i desenvolupar dos algorismes; un és capaç de predir si el pacient respondrà correctament a la Immunoteràpia o no i el segon és un algorisme que pot detectar i diagnosticar el càncer de mama!

3. Els pares de la IA

En un dels seus treballs de recerca, Andrea Kaplan i Michael Haenlein, defineixen el terme de la IA com un “sistema amb la capacitat d'interpretar correctament les dades externes, d'aprendre d'aquestes dades, i d'utilitzar aquests aprenentatges per aconseguir objectius i tasques específiques mitjançant una adaptació flexible.” Crec que aquesta és una definició tan gran del terme IA que defineix exactament com funciona.

L'univers de la intel·ligència artificial està cada vegada més present en les nostres vides. El terme intel·ligència artificial va néixer en els anys cinquanta, i actualment s'està desenvolupant i fent més gran d'acord amb la tecnologia del segle XXI; no obstant això, no seria possible sense els fonaments de les següents forces motrius:

- Alan Turing, precursor de la intel·ligència artificial i creador de l'ordinador.
- John McCarthy, que va crear el LISP, un llenguatge de programació que es va utilitzar per resoldre problemes, i va definir el terme IA com "la ciència i l'enginyeria de fer màquines intel·ligents."
- Marvin Minsky, matemàtic, físic i fisiòleg que va crear la primera xarxa neuronal artificial.
- Nat Rochester, que va escriure un llenguatge de programació de baix nivell.
- Claude Shannon, enginyer elèctric i matemàtic que va millorar l'arquitecta de les màquines de computació.

4. Tècniques AI

Moltes tècniques s’inclouen al camp de la IA; malgrat això, he decidit centrar-me en les tres més destacades que inclouen l'aprenentatge automàtic (Machine Learning), l'aprenentatge profund (Deep Learning) i les xarxes neuronals (Neural Networks).

En el meu treball de recerca m'he centrat en l’aprenentatge automàtic, un mètode que comença amb un objecte del qual un ésser humà omple les seves característiques en el sistema d'aprenentatge automàtic, de manera que la

pròxima vegada que el sistema es troba amb aquest objecte i el reconeix, és gràcies a la seva base de dades.

L'aprenentatge profund és una mica diferent, ja que és un subcamp d'aprenentatge automàtic i el seu sistema autònom aprèn de les dades en brut i pot augmentar la seva precisió si se li donen més dades. En altres paraules, com més estímuls rep, millor prediccions.

Finalment, les Xarxes Neuronals són un model per trobar una solució a un problema que s'ha generat. Això s'aconsegueix quan el programa informàtic aprèn de les dades, ja que és capaç de reconèixer i classificar la informació que rep per obtenir un resultat. Milloren les seves connexions, fent-les guanyar precisió.

5. L'impacte de la IA en humans

Molta gent té por de la revolució tecnològica de la IA. Vull fer-li saber que la IA no s'ha creat per a eliminar els llocs de treball de les persones, sinó per a resoldre problemes i cooperar amb les persones per a aconseguir tots els seus objectius i terminis de manera més ràpida i òptima.

La societat actual viu en un món en el qual les persones necessiten una manera més ràpida i eficaç per completar el seu treball i treballar constantment sense descans i aconseguir resultats satisfactoris; per això, sens dubte, necessitem intel·ligència artificial.

No obstant això, si la humanitat estés satisfeta amb una forma natural de viure sense el desig excessiu de conquerir l'ordre de la naturalesa, llavors la IA no seria necessària. No obstant això, no és així.

La història de la humanitat ha demostrat que els humans sempre volem més i millor. En el seu desig de fer que el seu treball i la seva vida siguin més simples, més fàcils i més eficaços, estan motivats per crear coses que facin que això ocorre i, en conseqüència, creen avenços al llarg dels anys. la IA és un dels

avenços realitzats pels humans que té beneficis, però també riscos. Peguem-los-hi una ullada!

6. Beneficis i Riscos de IA

En la nostra vida diària, la IA es reflecteix en gran manera en el nombre de serveis que tenim, inclosos els assistents en línia com Siri, vehicles autònoms com drones, jocs en línia com Chess, predir retards de vol, etc. Sobretot, en la societat, la IA s'ha tornat indispensable.

Ha millorat el control de la salut de les persones i fins i tot la IA ha evitat que la humanitat visqui en un món en el qual hi hauria caos de moltes maneres.

Malgrat això, AI porta amb si pros i contres. Molts d'aquests contres estan relacionats amb la desocupació, ja que molts llocs de treball seran substituïts per maquinària i, probablement, el treball humà ja no serà necessari per a aquestes tasques, però hi haurà uns altres tal com va ocórrer amb la 1a revolució industrial.

De la mateixa manera, les trobades personals es veuran afectades per les connexions virtuals. A causa d'aquest fet, els nens que creixen i els adults que ja són majors interaccionen amb les persones virtualment; en conseqüència, perden progressivament la capacitat d'interaccionar cara a cara i apreciar la comunicació no verbal.

No obstant això, també hi ha molts impactes positius en els humans. Molts professionals estan implicats en projectes que són funcionals gràcies a enginyers, científics, investigadors mèdics i físics, que poden dissenyar una IA per millorar el diagnòstic i els tractaments mèdics; També poden crear robots terapèutics socials per a les persones majors per combatre la soledat. Això és el que jo denomino una fusió del coneixement per al benestar del món.

7. Diagnòstic Mèdic AI

Avui dia, estem envoltats per una gran quantitat d'informació que pot generar enormes conjunts de dades i aprendre dins del procés. Un metge de l'antiga Grècia anomenat Hipòcrates va declarar que "és més important saber quin tipus de persona té una malaltia que saber quin tipus de malaltia té una persona." Amb els ordinadors, això es pot aconseguir fàcilment, ja que fan patrons per donar sortides com nosaltres mengem cada dia per sobreviure. Hauríem d'aprofitar-ho!

Des del meu punt de vista, crec que la intel·ligència artificial hauria d'aplicar-se gradualment. Si veiem que ajuda la medicina a aconseguir millors resultats, avancem. Si no ho fa, eliminem-la; però estic segur que això no ocorrerà.

El Human Diagnosis Project és una comunitat mundial de professionals mèdics dedicats a posar fi a un accés desigual al coneixement mèdic. El seu propòsit és compartir casos mèdics i rebre informació d'ells, ajudant els metges a elaborar el diagnòstic adequat per als pacients.

Per aconseguir aquesta relació, és necessari tenir una intel·ligència col·lectiva, que prové dels metges, i l'aprenentatge automàtic.

L'objectiu de la IA en el diagnòstic mèdic pretén ser més precís i assequible en el futur; d'aquesta manera, tots els països del món tindran accés al coneixement mèdic i no sols uns pocs. Sona genial, oi?

8. Reconstruir els valors en l'assistència sanitària

Va ser el 27 de febrer de 2020, mai oblidaré el dia en què el BOE, que significa "Boletín Oficial de l'Estado", va publicar el nou reglament que implicava només 20 minuts per visita de metges.

Aquell dia no vaig poder entendre per què la medicina era tractada com una empresa comercial. Les paraules clau de les quals parlaven eren la productivitat, l'eficiència, entre altres. En quin món es podria establir el temps necessari i estàndard en el qual es podria diagnosticar sense estar equivocat i fer el necessari per a salvar la vida d'un pacient? La resposta és cap. Aquest fet

provoca la majoria de les pitjors conseqüències per a la medicina, la deshumanització.

Des d'aquest reglament, la medicina s'ha traslladat encara més cap a una era d'errors, residus i mals resultats que ja existien llavors, però que encara són més presents ara.

El temps és un factor clau per a establir relacions amb les persones i encara més per a un metge que tracta a persones desconegudes cada hora. El punt principal en aquest cas és que sense temps no és possible un vincle entre el doctor i el pacient. No obstant això, tenim la sort de tenir la intel·ligència artificial en les nostres vides, ja que és el nostre donant de temps!

Perquè entenguin com podria participar la IA en el sistema sanitari, vull donar-los un exemple.

Imaginis que un pacient entra a la consulta i s'asseu davant el doctor. Al costat del doctor hi serà un assistent de la IA, el qual recopilarà i analitzarà totes les dades proporcionades pel pacient, però també tindrà en compte la història mèdica del pacient per fer un bon diagnòstic.

Mentrestant, el metge escoltarà atentament i amb contacte visual el pacient. Per això els metges són essencials, ja que fer el diagnòstic no sols implica dades, sinó també els sentiments del pacient i les paraules que estan entre línies, que només es poden escoltar quan els metges són presents.

Mentre el metge i el pacient estan conversant i establint confiança entre ells, l'assistent mèdic recopilarà dades. D'aquesta manera, juntament amb els metges realitzaran un gran diagnòstic.

La figura del metge és fonamental no pel seu coneixement, sinó per la seva humanitat. L'empatia, la presència, l'observació, l'atenció, la comunicació i l'examen físic és el que caracteritza el nostre humanisme; aquest és el camí que hem de seguir per a fer que l'atenció sanitària torni a ser humana.

Aquestes interaccions humanes no són fàcils de quantificar, ja que totes són de naturalesa emocional. Per això un metge és essencial per a la medicina i no pot ser substituït per màquines, ja que els pacients necessiten humanisme, i aquest ha de venir dels metges.

Hem demostrat que la IA ens dona temps per a ser humans en el nostre treball i reforça les decisions del metge; què estem esperant per a aplicar-la?

9. La Siri mèdica

És fàcil fantasiar sobre la idea de tenir una Siri mèdica per cuidar-nos i millorar la nostra salut. No obstant això, la creació d'aquesta comporta un repte multifàsic que inclou qüestions polítiques i tecnològiques.

Si la siri mèdica es millora en els resultats i es redueix en els costos, un ciutadà amb un salari estàndard s'ho podrà permetre i la pagarà. No obstant això, si permetem que aquests dispositius es comprin, s'accentuaran encara més les desigualtats en l'atenció sanitària. Per no esmentar que als països no desenvolupats aquesta tecnologia ni arribaria.

Per això crec que aquesta tecnologia no hauria d'anar més enllà dels hospitals, ja que, d'aquesta manera, s'evitarien les desigualtats mèdiques entre els països i, en conseqüència, la creació de moltes siris mèdiques a l'hospital es veuria afavorida, ja que donarien suport a la veracitat de les decisions d'un metge.

10. Marc pràctic

Fins a aquest projecte, havia utilitzat Excel molt poques vegades i això m'espantava una mica. No obstant això, crec que es tracta d'una aplicació gran i multidisciplinària en la qual es poden desenvolupar grans coses com un algoritme.

Encara que he desenvolupat dos algoritmes en el meu treball de recerca, en aquest resum he decidit explicar el primer ja que el mètode per als dos

algorismes és el mateix. Aquest va ser l'algorisme que va predir el càncer de mama.

Bé, en un algorisme KNN sempre hi ha una referència des de la qual comencem a calcular. En aquest cas, tindrem un pacient de referència. El que ens interessa a continuació és calcular quins són els pacients més pròxims al pacient de referència. Per a això, calculem les distàncies dels pacients.

Quan sapiguem quines són les més properes, identifiquem el seu tipus de tumor. En el càncer hi ha dos tumors possibles: benigne i maligne. El primer serà el tipus 2 i el maligne tipus 4, d'acord? Si té majoritàriament tumors benignes al seu voltant, el pacient de referència també s'identificarà com a tumor benigne. D'aquesta manera, he predit el càncer de mama en un conjunt de dades de més de set-cents pacients. Aquest algoritme ha demostrat una precisió del 95%.

11. Conclusions

Per a acabar, puc afirmar que amb aquest treball de recerca he demostrat que la intel·ligència artificial és una prova que la ciència i la tecnologia poden fusionar-se per a aconseguir una cosa més gran; IA és una prova que tenim tot el que necessitem aquí a la Terra per a crear solucions a les nostres preocupacions. La nostra supervivència només depèn de la direcció en la qual ens centrem.

Fer aquesta feina d'investigació ha estat un plaer per a mi, ja que he conegut gent meravellosa que sap d'intel·ligència artificial i que m'han obert els ulls a aquest món increïble al qual ja no vull tancar.

Gràcies a Déu i a la meva insistència, he realitzat un marc pràctic que correspon a les expectatives que tenia des del principi. He desenvolupat dos algoritmes amb una precisió increïble i crec que he contribuït una miqueta a la societat i, sincerament, aquest sentiment és molt agradable.

El pronòstic del càncer de mama és una garantia que la persona en aquestes circumstàncies superarà amb èxit aquesta malaltia i es farà més forta.

Al llarg d'aquest treball de recerca, he descobert moltes coses. Una d'elles és que tot el que faré en el futur serà per ajudar a la humanitat. Vull deixar el món millor del que el vaig trobar al néixer. Per fer això, m'he adonat que la medicina necessita un canvi.

Els canvis requereixen esforç, ja que hem d'adaptar-nos a ells, però, junts, estic segur que podem desfer-nos de la por i aprofitar l'eina més poderosa que ha existit en la humanitat, la intel·ligència artificial.

La medicina necessita una transformació per a convertir el sistema sanitari d'avui en un sistema que les seves preocupacions estan relacionades no amb el temps, sinó amb el pacient, no amb el tractament que serà bo per a la població, sinó amb el tractament que s'adapti a les necessitats del pacient, no amb curar una malaltia, sinó amb sanar-la, no amb el hackeig, sinó amb la privacitat del pacient, no amb la distracció, sinó amb l'atenció i la presència, no amb la distància, però sí amb la proximitat, i no amb la cura de la malaltia, sinó amb la prevenció d'aquesta.

Vull unir-me a aquest equip de salvadors, vull ser una gran doctora i vull formar part d'aquest ambiciós desafiament sanitari perquè vull enfocar la medicina actual cap a una medicina tecnológica més humana que mai abans, gràcies a la Intel·ligència Artificial que ens donarà el temps i les eines necessàries per aconseguir-ho.

"A"

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1.0 INTRODUCTION

The title of this paper is *"artificial intelligence: the (r)evolutionary way to transform medicine."* My research is centered on introducing an effective technology with minimal margin for error, such as AI, to improve current medicine by avoiding misdiagnosis and malpractice, and thus offering the most valuable gift to physicians: time.

The choice of the theme of this work is based on my idol. She is Kavya Kopparapu, a young computer scientist who has developed software that uses deep learning to determine brain tumor's molecular and genetic signature.

However, her method can be accomplished in a fraction of the time and cost of traditional methods! Incredible, isn't it?
So, as soon as I finished reading all about Kavya Kopparapu, I thought she was a clear example to follow, and that's how the power of artificial intelligence came into my hands.

The power of artificial intelligence involves many areas; notwithstanding, I have decided to focus on the field of medicine in this project. Through this research work, you will be able to appreciate that AI can promote our health, prevent diseases, detect them faster, and even be a time-giver! That's why through examples I will show you, the reader, the different types in which AI can make lives easier and safer.

I am excited about the future; about the power of AI and all the data collected. There are no decades left; this revolution is ushering the world into the 4th industrial revolution. Let's get in!

2.0 GOALS & HYPOTHESI

The objectives I have set for this research work are the following:

- To learn, to know, and to deepen in the world of artificial intelligence; concretely in the area of medicine.

- To let the reader know in-depth and from an objective perspective the advances that artificial intelligence will bring to our medical system.

- To determine how artificial intelligence could allow improving the quality of life of the patients.

- To show the type of medicine practiced today as well as to envision the ideal medical system of tomorrow, which would bring with it AI.

- To learn about the history and current affairs in the world of artificial intelligence and medicine, how they work in both fields and what is expected in the future of these scientific and technological branches.

- To carry out a practical framework in which to be able to apply AI to medicine with the bibliographic search that will allow me to create an algorithm that detects breast cancer.

- To know the laboratories where computer scientists, mathematicians, among others, develop algorithms.

- To quantify through surveys, the knowledge people have about the implication of AI in healthcare.

- To evaluate my autonomy and independence to face research work.

And with all these series of objectives, I intend to corroborate or disprove my hypothesi:

“Perhaps, the awesome power of AI can make medicine better and even make humans healthier and more human.”

3.0 METHODOLOGY

To corroborate my hypotheses, first of all, it is necessary to know more objectively about the birth of AI and its history up to the present day. For this reason, the first part of the body of the paper focuses on its origins, its impact on humanity, its benefits and risks as well as the ethical aspects, and finally, the techniques and the applications of AI that we use in our lives.

Therefore, in the second part, I have sought to merge the term medicine with AI so that you, the reader, could understand the importance that AI suggests in the healthcare system. To accomplish this, I have applied the knowledge from the first block to the second one.

Thus, in this second part of the theoretical framework, I have focused on diagnosis, patient monitoring, personalized treatment, the virtual medical assistant, the more abstract elements that make the healthcare system quality, as well as privacy and hacking, all of them accompanied by AI.

This bibliographic research aims to obtain a solid theoretical basis to tackle the subject with the maximum evidence, selecting the information that best suits the objectives and reinforces the hypotheses.

To do literature research, I have read books, scientific articles from indexed journals of international impact, and scientific dissemination websites.

In the same way, I have used all the knowledge acquired in the theoretical framework to carry out my practical part. This consisted of developing an algorithm that could detect breast cancer and I succeeded with the unmeasurable help of Dr. “x”, Ph.D.

The interest and originality of my project lie in getting into the field of research to achieve my objectives and obtain the best possible knowledge on the chosen topic.

4.0 ANALYSIS OF THE SURVEY

Artificial intelligence, also known as AI, is the most powerful tool that has ever existed in humanity and my project shows this. But what about the normal person on the street? What does a normal person understand about the phenomenon of AI?

Before I started doing my project, I decided that at that moment it would be a good idea to do a survey to see what people knew. Talking with my tutor, we decided that it would be better to do it before I found out more information, so as not to “corrupt” the survey with ideas that I was going to learn.

In hindsight, it was a wise decision because the questions were not based on what I now know, but on what I thought would be reasonable questions that a person on the street could answer so as to give me an idea about what people knew about artificial intelligence.

From the results of the surveys I have been able to extract some points that have helped me to corroborate some parts of the document based on the objective data it provided me with.

There were two surveys. The first one was answered by 402 people while the second one, which was geared exclusively to Batxillerat students, had a total of 34 responses.

The majority of those that answered were female. To understand why more females answered could be the topic for another TDR, so I won't try to answer that question. What I will do is try to explain the information that I can extract from those who answered and not take into account whether they are male or female.

In the first survey, the vast majority of the people who answered were over 30 years of age, 75.9%, of which 60% were working or at university. Of all those who answered, 81.5% had heard of AI so I felt that their opinions about AI would be interesting. Yet a further 70% of those who answered were not able to mention one of the main aspects of AI. When asked about each of the main aspects, in all cases over 70% of the respondents did not know what it was.

In the second survey which was carried out only among Batxillerat students, the results were more positive in that more people seemed to understand the aspects of AI. Over 84% of those who responded had heard of AI and over 50% were able to identify some aspects of AI.

This indicated that younger people had a better understanding of the concept of AI.

As for what AI can be used for, in both cases the vast majority answered that AI could be used everywhere, comparing the results between both surveys, survey 1 = 86%, survey 2 = 93.8%. It is clear from this that although most people cannot identify specifically AI they know that it is out there.

The two final questions about AI were about the implications for humanity in the future. In both surveys the majority were not able to say if AI would be beneficial for humans. Even so, in the first survey only 7.1% thought it would not be good for humans whereas in the second survey, 0% thought it wouldn't be good. This leaves a sign of optimism as according to these findings, people will accept AI.

In conclusion, I believe that artificial intelligence just needs more explanations to people about its future uses and that is definitely what I am here for. In this paper I will explain to you in detail all the benefits, risks and its impacts on humanity. Are you ready for it? I am glad you are here walking this path with me. Thank you!

5.0 ARTIFICIAL INTELLIGENCE

5.1 ORIGINS AI [1]

The universe of artificial intelligence is increasingly present in our lives. However, the research and study of intelligence has a lot to do with civilization itself.

The ability of humans to think for themselves, to understand and resolve conflicts both simple and complex show our admiration for this naturally occurring process, which scientists and philosophers alike have the desire and hope to discover how it is produced.

[1] History AI and its founders

It is worth mentioning Alan Turing[2], the theoretical father of the computer and the precursor of artificial intelligence.

In his youth, Turing was a genius in mathematics. So, he was admitted to the University of Cambridge. There, he demonstrated what was computable and what was not. Whatever could be solved with an algorithm, which is a set of steps to be followed by a computer, was computable, the rest were non-computable tasks. Although his project never materialized, it was designed to execute mathematical operations through an algorithm and, if programmed, transformed into a computer. In addition, he is also known for being the decoder of the Enigma code, one of the projects of World War II.

Artificial intelligence comes from the four main fathers: John McCarthy, Marvin Minsky, Nat Rochester, and Claude Shannon.

John McCarthy[3] came from a poor family. They moved into California where he studied Mathematics and three years later, John received a Ph.D. from Princeton in the same subject. He never stopped studying the way a machine could think like a human and in this way, he spread his passion to the whole world, concretely, in 1956 at Dartmouth's conference; he explained for the very first time the concept of AI as *"the science and engineering of making intelligent machines."*

Although machines at that time weren't as powerful as nowadays he stated that "*The speed and memory capacity of today's computers may be insufficient to stimulate many of the more complex functions of the human brain, but the main obstacle is not the machines' lack of capacity, but our inability to write programs that fully exploit what we have.*" For that, he found the solution to solve the problem he had creating LISP, a programming language that was used to implement techniques for theorem proving, mathematical problem solving, game theory, etc.; it became the official language of the time for AI.

[2] The true father of AI
[3] John McCarthy and the beginnings of AI

Marvin Minsky[4] was born in New York in 1927. Minsky studied physics, mathematics, and physiology at Harvard and Princeton. Marvin, jointly with John McCarthy, was one of the founding fathers of the Laboratory of AI at MIT, which acronym means Massachusetts Institute of Technology. There, he formed and stimulated several generations of computation and created a passion for making science. Besides, he is considered the creator of the first artificial neural network which was able to learn. It was called SNARC and this constituted the base of Machine Learning.

Likewise, Marvin Minsky claimed that *"each human mind is the switch of a committee of minds of lesser power that converse with each other and combine their respective abilities to solve problems."* This quote shows how Minsky used to look at problems; from many angles which could give him many perspectives to any thought he might have.

Nathaniel Rochester[5], also known as Nat Rochester, wrote the first assembler which is a low-level programming language that allowed programs to be written in readable commands instead of pure numbers or complex codes; Rochester also participated in founding the field of artificial intelligence that is why he is considered one of its fathers.

In the summer of 1955, John McCarthy jointly with Marvin Minsky had a proposal to Nat Rochester and Claude Shannon, holding a conference about artificial intelligence in which would assist all who worked in this field. They achieved their goal and in the summer of 1956 the *"Rockefeller Foundation"* supported the conference with 7,000 dollars.

Claude Shannon, in 1932, attended the University of Michigan, where he studied electrical engineering and mathematics, graduating in both fields in 1936. Then, he found a way to combine his repair skills with his knowledge of electrical engineering by working in the Electrical Engineering department at M.I.T.

[4] Marvin Minsky, the brain behind artificial intelligence

[5] Biography of Nathaniel Rochester

Like Alan Turing,[6]he took part in World War II in some projects. The first one was focused on the control system prediction while the second one was directed to decode confidential messages. He also created *"A Mathematical Theory of Communication"* which showed that by making a good choice of transmitter and receiver it is possible to send messages with accuracy and confidence.

In a way to combine his repair skills with his knowledge of electrical engineering and mathematics, he was one of the pioneers of artificial intelligence. Shannon was the co-author of the *"Proposal for the Dartmouth*[7] *Summer Research Project on artificial intelligence"* which led to the birth of the concept of artificial intelligence.

There, McCarthy, Rochester, Minsky, and Shannon showed to all the people who assisted in the conference that their goal was to *"proceed based on the conjecture that every aspect related to learning or any other feature of intelligence can be described so accurately that a machine simulates it."*

Shannon wanted to implement his *"Mathematical Theory of Communication"* to establish a reliable transmission of information in computing machines.
This helped to improve the architecture of computing machines.

In 1943, Warren McCulloch and Walter Pitts proposed a neuron model of the human and animal brains. These types of nerve neurons symbolically represent brain activity. A few years later, Norbert Wiener created the concept of cybernetics, a science that studies the functioning of the mechanisms and nervous connections of living beings. A few years later, Claude found that any brain model could adapt to its environment which was related to a project that consisted of a mouse finding its way in the labyrinth.

Thanks to their collaboration, the term artificial intelligence was born and nowadays it is being developed and made bigger according to the technology of

[6] What did Alan Turing bring to science?
[7] Dartmouth Conference

the XXI century; However, it would not be possible without the foundations of the driving forces; John McCarthy, Nat Rochester, Marvin Minsky, and Claude Shannon.

5.2 THE AI'S IMPACT ON HUMAN

Many people are scared about the technological revolution of AI. In this section, my purpose is to make you conscious of the pros and the cons of AI and its impact on humankind. [8]

Artificial intelligence, also known as AI, has many different definitions; according to Andreas Kaplan and Michael Haenlein, who are two experts in the area of social media and artificial intelligence whose research is focused on analyzing, understanding, and decrypting the digital world, stated that artificial intelligence is *"a system with the ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation."* So, with this definition, it doesn't seem that AI is created to take away people's jobs but to solve problems and cooperate with people to achieve all their objectives and deadlines in a faster and optimal way.

However, businesses started to realize the limitless capabilities of AI; for that, they have used it to boost production, development of new products, and solving problems that humans can not. It can be seen that the purpose is not making machines think like humans, but better and faster than them. Notwithstanding, why do people believe that this fact must be detrimental to humanity?

My grandma and my mum used to say to me when I was younger that *"the influences you hang out with shape you into the person you are."* That is why I always try to get together with smart people with great values. In AI's case, if robots are smarter than us humans, humans will learn from them. Thus, what is the problem? Cannot learning from a robot be considered as valid as learning from a human? I think so.

[8] AI And Its Impact On Humanity

The current society lives in a world where people need a faster and effective way to complete their work and to work constantly without taking a break; that is why we definitely need artificial intelligence.

However, if humankind was satisfied with a natural way of living without excessive desires to conquer the order of nature, it is not.

The history of humankind has shown that humans always want more and better. In their desire to make their work simpler, easier, and more effective, they are motivated to create things that make that happen and consequently create progress over the years. AI is one of those advances made by humans that has benefits but also risks. Let's take a look at them.

5.3 BENEFITS AND RISKS OF AI

In our daily life, AI is highly reflected in the number of services we have including online assistants such as Siri, autonomous vehicles such as drones, playing games online like Chess, predicting flight delays, medical diagnosis, and image recognition in healthcare, and even performances on open surgeries. Above all, in society, AI has become indispensable. It has improved people's health monitoring and even AI has avoided humankind to live in a world where there would be chaos in many ways.

Notwithstanding, AI brings with itself pros and cons. Many of these cons are related to unemployment since many jobs will be replaced by machinery and probably, human labor will not be necessary for these tasks anymore since the digital era can take over it. But there will be others!

In the same way, the personal gathering will be affected by the virtual connections and their amenities. Due to this fact, children who are growing and adults who have grown will interact with people virtually; consequently, they will progressively lose the ability to interact face-to-face, appreciate non-verbal communication, and even establish true bonds of friendship.

According to Aristotle, who was a Greek philosopher that was taught by Plato, he affirmed in his quote that *"Friends for a season, friends for a reason, friends for life"*, Froding and Peterson in 2012 stated that Aristotle's theory of friendship shows how virtual relationships do not even qualify as genuine friendships. Other philosophers have also interpreted that Aristotle's theory considers an authentic friendship when there is human interaction, moral behavior, love, and admiration within them.

There are, however, many positive impacts on humans as well. Healthcare is the emerging field in AI that will bring more benefits to the current health system and the patients.

Many professionals are involved in projects consisting of engineers, scientists, medical researchers, and physicists, who can design an AI that is functional in diagnosis and medical treatments. This is what I call a fusion of knowledge for the welfare of the world.

In healthcare, professors are searching for efficient ways of treating pathologies with digital computing and robotic systems to create accurate medical procedures. However, the applications do not end here.

An IBM's Watson[9] is a computer able to solve problems and give responses to questions formulated in programming or natural languages. It is used for businesses since it helps companies and administrations to predict future outcomes, optimize employee's time, and so on.

Thus, IBM's Watson is used to make diagnoses and it is doing amazingly well. In its procedure of a physical examination, it will provide whether or not the patient suffers from disease and even will suggest some treatments!

To combat loneliness in elderly people and even in middle-aged people, engineers and technicians are working to create social therapeutic robots. It is predicted that they would reduce anxiety and blood pressure levels and increase social interaction.

[9] AI is the future of business. Watson is helping enterprises put AI to work.

However, there is some uncertainty about the answers that people, especially the older, will give. I strongly believe that to have a better reception in society, the robot should not look like a human since it would provoke a sense of fear within the society of being replaced soon.

Likewise, it is common among surgeons the appearance of fatigue after hours and hours of intensive surgeries. What characterizes humans is the passion for food but also the higher risks of making errors! That is why we should contact AI which has the perfect solution to this matter. Its contribution is based on robotic technology which allows the surgeons to operate with minimally invasive procedures. This system ensures accuracy and precision in the surgery. With less invasion, less trauma, and consequently the patient will have a better recovery period.

Notwithstanding, these procedures still need to be operated by health professionals but AI can make part of the work causing less damage to the patient. So, its contribution gives doctors time to recover and rest with the security that it will accomplish the duty faster and successfully.

According to Michael Cheng-Tek Tai of the Department of Medical Sociology and Social Work, College of Medicine, Chung Shan Medical University, Taichung, Taiwan, the virtual presence will enable a tele-diagnosis by the doctors to the patients. It won't be necessary to have a physical presence to check the patient, only a robot that will interact at the same time with the patient and the doctor to ensure communication between them. This breakthrough will help people with disabilities who have reduced mobility, are blind or deaf-mute, and ensure their safety. It will even help those who live far away from the hospital so it will be a great way to reduce transportation costs.

5.4 ETHICAL JUDGMENT ON EUROPE

As AI becomes more prevalent day by day, the potential to suffer harm from it increases in the future. This is not only about artificial intelligence benefits but also about the dangers. In this field, there is a lot of concern about medical data;

if this is not appropriately secure, hackers can make dreadful use of it, implying a risk to the patient's privacy.[10]

Notwithstanding, humans can clear frameworks to show society how their data is being used by healthcare staff. In this way, the patient's trust among the physicians, surgeons, and many other staff would help to enable the progress of the mathematics algorithms on healthcare and even to install them to be functional. Definitely, with confidence in people's minds, mathematicians and computer scientists would get better day by day without fear and concern being unstoppable. [11]

5.4.1 ALAN TURING & SUM

To improve the safety of society, Alan Turing, who I mentioned in point 4.1, created an ethical judgment. This is called SUM which means "Support, Underwrite, Motivate" in a responsible innovative way.

According to the *"European AI Alliance,"*[12] there are four main values introduced in the SUM judgment of any AI project: respect, connection, care, and protection.

The dignity of individual people must be **respect**ed by mirroring their self-independence and even their self-acknowledgment and thriving.

The **connection** with humans must be with transparency and integrity. They also need to search for the creation of interpersonal relationships and build them in a truly inclusive way.

[10] The ethics of Artificial Intelligence: Issues and initiatives
[11] Ethics of Artificial Intelligence and Robotics- Stanford Encyclopedia of Philosophy
[12] The Alan Turing Institute publishes a comprehensive guide for the responsible design and implementation of AI systems in the public sector.

The **care** for the prosperity of humankind must represent values such as contribution, security, and non-harm, as well as stewardship of the biosphere to improve it and ensure a future on Earth.

In an AI project, the needs of social values must be secured but also the public interest in it. This can only be achieved through legislative laws that ensure AI makes decisions in a way that safety is guaranteed especially for children and the elderly. This would give **security** to society that would trust even more in this amazing technological tool which has already begun.

5.4.2 AI & FAST TRACK PRINCIPLES

The “Fast Track Principles” is another tool used in Europe to establish the basis of ethics in AI, which helps AI systems to apply an ethical design into an algorithm in practice following these principles: fairness, accountability, sustainability, and transparency.

The principles of fairness and sustainability are qualities of algorithmic systems, which are crucial aspects that are included in the design, implementation, and outcomes of such systems.

According to **fairness**, designers are building algorithms that cannot harm anyone for discrimination or intolerance.

Conformed to **sustainability**, engineers and mathematicians are implementing AI for innovation that is safe and ethical in its outcomes and impacts on humans and on Earth.

The principle of **accountability** refers to that humans are responsible for their roles throughout the AI design and implementation processes. It also requires that the work's outcomes must be traceable from beginning to end.

The principle of **transparency** entails that all designs and development processes must be fully justified. It also requires AI capabilities to be interpretable and understandable to those affected.

However, there is already the third technique in the framework used in Europe on ethical issues with artificial intelligence. Let's take a look at it!

5.4.3 AI & PBG Framework

The *"Process-Based Governance System,"* also known as PBG Framework, is the framework's third technique that will be used to implement ethics in AI.

The PBG Framework provides technical and non-technical resources such as processes, procedures, rules, and records to assist AI developers and intended users to put ethical values and concepts into effect.

5.5 AI TECHNIQUES

5.5.1 MACHINE LEARNING

Machine Learning[13] is a sub-field of computer science and a branch of artificial intelligence whose purpose is to develop techniques that enable computers to automatically improve through experience and making it a fundamental pillar of large-scale data processing.

This technique creates algorithms that can generalize behaviors and recognize patterns based on examples. So, it can obtain a global statement from statements that describe particular cases. Consequently, it can predict future behaviors from past ones. That's amazing, isn't it?

Nevertheless, to make that possible, it is required to feed the experience of the machine through *"examples"* in order to apply patterns, which have already been recognized, above other different objects.

[13] Introducción al Aprendizaje Automático-Fernando Sancho Caparrini

This type of learning is called **inductive learning**, a process where the learner discovers rules and behaviors by observing examples. On the other hand, **deductive learning** is applied when learners are given rules that they then need to apply.

There are some types of inductive learning; they are *"Regression"*, *"Classification", and "Ranking."*

- **Regression**: It predicts future values from past data. One example is the stock market.

- **Classification:** This type of inductive learning predicts the classification of a set of prefixed classes. If there are 2 classes, it will be called binary classification; however, if there are more than two, it should be nominated as multiclass classification. This is applied to the TV news to classify the different rates of news.
- **Ranking:** It tries to forecast the optimal order of a group of objects in a function according to the predefined order of relevance of them. For instance, this can be seen in a search when a user is looking for something, so the search results would be determined by this type of inductive machine learning, ranking. These would be sorted with search-related precision.

These types should be categorized since depending on how they are classified, it will be how humans can measure the error made between prediction and reality which will focus them in a completely different way.

So, they can be categorized through six different learning kinds:

- **Supervised Learning**: It establishes a function between the inputs and the outputs in which the knowledge of the system is formed by labeled examples.

- **Unsupervised Learning**: In this case, the knowledge is only formed for inputs and not for outputs. The inputs are unknown; that is why it is sought to recognize patrons to label the new inputs.

- **Semi-supervised Learning:** It is a combination of the above ones since this kind of learning presents both categorized and unclassified examples.

- **Reinforcement Learning:** In this type, the algorithm learns by observing all around. In this way, he receives information from the world and gives outputs to the same. Thus, from the trial-error process, he incorporates everything that has a positive response in the world.

- **Transduction**: Its main goal is to predict which would be the correct classification from the examples based on the inputs and the new inputs.

- **Multi-task learning:** This includes all those learning methods that use the knowledge the system has previously learned to solve similar problems to those that have already been categorized.

In my practical part, explained in more detail in point 6, I will be doing a program based on a supervised algorithm called K-NN which means K-**N**earest **N**eighbors. It will consist of developing an algorithm able to detect through data breast cancer in each type of patient.

The attributes will be related to clump thickness, uniformity of cell size and shape, adhesion, epithelial cell size, bare nuclei, bland chromatin, normal nucleoli, and mitosis. They will be measured among parameters from one to ten to get classified in which class of tumor they belong to. Those who have a "two" in the results will be benign but those who have a "four" will have breast cancer.

As I have explained before, the algorithm is one of the simplest that exists in AI. However, it is a good way to put into practice Machine Learning and see how artificial intelligence acts to make a reliable diagnosis.

5.5.2 DEEP LEARNING

Deep Learning[14] is a class of algorithms used in Machine Learning; it simulates the brain's behavior through Neural Networks. These *"artificial neurons"* have a similar structure to mammals; consequently, humans and NN work in the same way to get a result that would be as close as possible to what a human being would have had thought. So, in this way, through Deep Learning we extract useful patterns in raw data, and thanks to these features, the Neural Networks will learn how to perform a task directly from data.

Our brain is structured in areas; each area is determined by Neural Networks which have a concrete function within our brain. The same occurs with *"artificial neurons"* since they are distributed between levels or layers where the Neural Networks are responsible for recognizing and qualifying either only one feature or more abstracts and generic patterns. Their goal is getting an output reliable to humans.

In this way, Deep Learning is approaching us to a new era of automatic learning which allows human beings to take a step forward in a good direction and discover more features that with simple data we could not be aware of.

Consequently, this is an improvement in computational perception which affects different areas such as language and learning. It provokes an approach to human conditions or even an overcoming of them! I am referring to intelligence, memory, reasoning, attention, and so on… That's fabulous!

So, humans can ask machines directly and expect an incredibly intelligent response. The responsibility is now on the human roof to ask them good questions to improve our world with the incredible power as is AI.

[14] Deep Learning: qué es y por qué va a ser una tecnología clave en el futuro de la inteligencia artificial.

5.5.2.a THE DIFFERENCE BETWEEN DEEP LEARNING AND MACHINE LEARNING [15]

Ok, but you may ask: what is the difference between Machine Learning and Deep Learning? Well, all of them are indeed ways to apply artificial intelligence to our lives. However, the distinction between them is in human involvement in all these types of learning.

In Machine Learning, we need humans to teach it while Deep Learning is more autonomous, which means that they don't need so much engagement with the process.

On one hand, the Machine learning method starts with an object from which a human fills its characteristics into the machine learning system so that the next time the system encounters that object and recognizes it, it is thanks to its database.

On the other hand, in the deep learning process, the system learns from the raw data and can increase its accuracy if it is given more data. In other words, the more stimuli it receives, the better its prediction.

To sum up, a machine learning system has to be taught what are the main features; in this way, the program will recognize the object that it is seeking.
However, in a deep learning system, there is no need to describe the characteristics of the object, although it is fed with images so that it learns on its own with lower human involvement than machine learning.

5.5.2.b THE BUILDING BLOCK OF THE DEEP LEARNING: THE PERCEPTRON

According to McCulloch, *"The brain is an intelligent problem solver, so we have to imitate the brain."*

[15] Deep learning: ¿se pueden programar las máquinas para pensar como humanos

If we consider the great complexity of the brain, we can predict that the possibility of achieving it is difficult; not to mention that technology seventy years ago was not even half developed comparatively to follow the behavior of the brain as we are now.

Though, humans began to be considered as a succession of simple tasks which were related to symbols. Despite this consideration, the most difficult task was and is to link these *"simple tasks"* together.

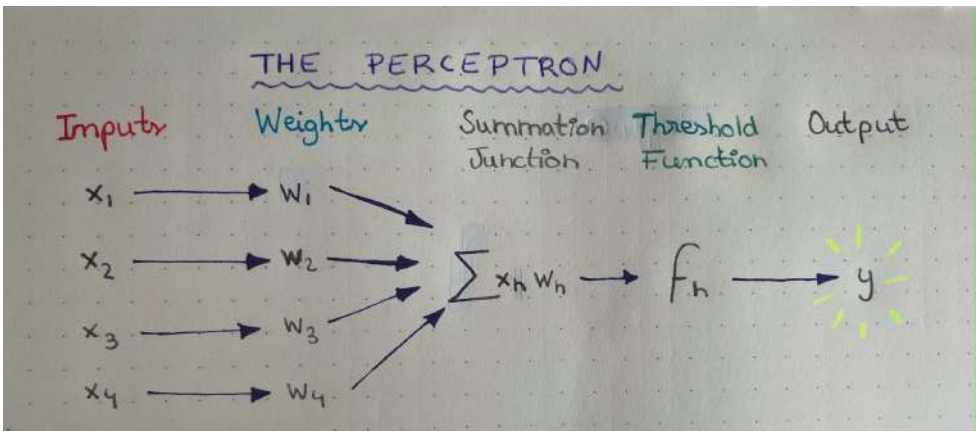
In the 1950s, *"The Perceptron"* was developed by Rosenblat, concretely in 1959. It is a visual pattern recognition system and its operation is very simple. It simply reads the input values, sums all the inputs according to weights and feeds the result into a threshold function[16] which is a function that takes the value one if a specified function of the arguments exceeds a given threshold, and zero otherwise; in this way, the perceptron generates the final output.

The training of the perceptron[17] consists to determine the weights and thresholds which best match the input to the output. For the determination of these variables, a process is followed.

It starts with random values and modifies these values according to the difference between the desired values and those calculated by the network. To sum up, the perceptron learns interactively and its criterion for deciding this depends on the final result of the summing junction, which can only be either one or zero.

For example, if the value of the summation junction and the bias is less than one but greater than zero, the output of the neuron will be one. In the same way, if the value is less than zero the result will be zero and not one.

[16] Threshold Function Definition
[17] El perceptrón y su funcionamiento



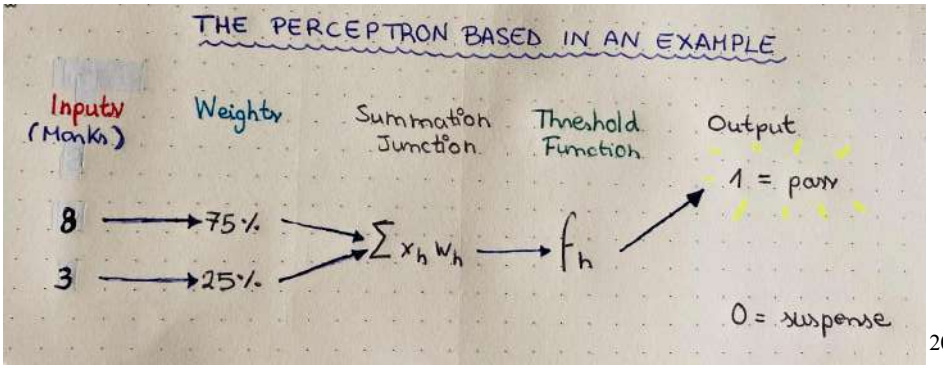
[18]

Let's give an example that will clear up the concepts for you.[19] This will be related to the finals in a school situation. The inputs are the two test scores. If the output is one, which means that the sum of the grades by their corresponding weight is greater than five, it is a pass! If it is zero, it is a fail. The weights are what we have to find and change with the training to get the proper results.

In this case, our training will consist of starting with two weights; for example, 50% and 50%, the same weight for each exam and see which result the neural network gives for each student. If it fails in any case, we will adjust the weights little by little until everything is well adjusted.

For example, if a student with a very good grade in the second exam has failed the course, we will lower the weight of the second exam because it does not influence too much. Little by little, we will find the weights that fit the teacher's final grades. The idea of the adjustment or feedback is to adapt the network to the *"hidden"* information in the data; in this way, the machine is learning!

[18] Figure 1. The Perceptron
[19] Las redes neuronales: qué son y por qué están volviendo



[20]

As I said before, this is a simple example. This can get complicated by putting more tests, which means more inputs, or wanting to get more results, such as a perceptron whose output may be *"one of the students must repeat the course"* or *"one of the students has an honors degree."*

5.5.3 NEURAL NETWORKS

The first Neural Network was created by McCulloch and Pitts. Their model was a binary model in which each neuron had a threshold, and served as the basis for later models.

In the current models, a Neural Network[21] is formed when it is connected to another and they are sending messages to each other to solve a problem that has been generated. To solve the issue with total success and dismiss failure on it, they improve their connections, making them gain precision.

Their models can be classified as:

- **Biology models** whose networks attempt to simulate biological neural systems, as well as certain functions. A current example would be the vision.
- **Applied artificial models** are models that don't need to be strictly similar to biological systems as their structures are closely linked to the needs of the applications for which they are designed.

[20] Figure 2. The Perceptron based on an example
[21] Las redes neuronales: qué son y por qué están volviendo

To conclude, we can say that Neural Networks are a model to find a solution to a problem that has been generated. This is achieved when the computer program learns from data as it is capable of recognizing and classifying the information it receives to get a result.

Therefore, according to neuroscience, Neural Networks are based on how we think and how our brain works. That is why, they can help us to understand our brain, improve our health, and even achieve the best connections between our neurons due to their ability to learn from data.

5.5.3.a BIOLOGICAL NEURAL NETWORKS

It is estimated that the human brain contains more than one hundred billion neurons and 10^14 synapses in the nervous system. A synapse is a junction between two nerve cells and at this moment a nerve impulse passes from one neuron to another. According to the studies of the anatomy of the brain, there are, in general, more than 1,000 synapses on average, at the input and output of each neuron.

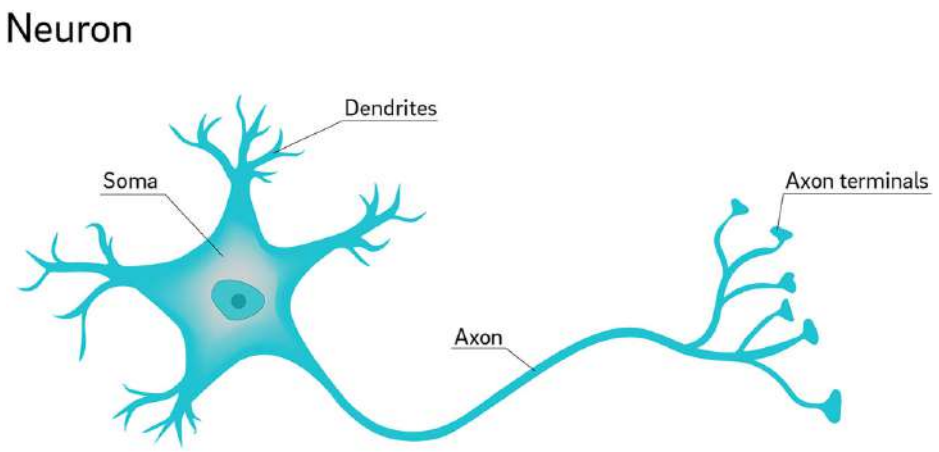
Although all the advances that there have been until now, natural neurons have thousands of times more connectivity than artificial neurons.

However, the main goal of artificial neurons is not to overcome these connections, but also to develop operations of synthesis and processing information that is related to any biological system.

Here you have a neuron. Now, let's go to see how they work to transmit the nervous impulse.

It has a *"body"* through which neurons emit and receive nerve impulses. In addition, it has dendrites which are neuron appendages that receive inputs from other cells. Finally, the axon carries the neuron's output to the dendrites of other neurons using electrical potential differences. Concretely, the axons use the

sodium-potassium bomb that, with the perfect conditions, allows the transmission of the nerve impulse.



[22]

5.5.3.b ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks indeed have been created with biological principles; but due to their multiple functionalities, they have become great neural networks since they offer improved possibilities for adaptive processing due to the algorithms they use.

In addition, because of their nonlinear processing, their capability to approximate functions, classify patterns and information, and even isolate the network from *"noise"*, which is the unwanted data that interfere with the signal, increases with these types of neural networks.

[22] Figure 3: Why are Neuron Axons Long and Spindly?

To conclude, although they don't overcome the number of connections that the Natural Neural Networks have, they are also a great alternative to many other functionalities that may need a neural network.

5.6. AI MEDICAL APPLICATIONS

5.6.1 AI MEDICAL APPLICATIONS OF TODAY

Nowadays, medicine is far from the inevitable transformation of the following years as to why consumers need to be fully engaged. However, there are three basic applications in current medicine.

On **Diagnostic and treatment support, AI thresholds** systems can reason, think and learn, making machines more efficient and helpful for doctors. For instance, a computer program can compare an image or a scan of a tumor and compare it with its database which will establish if the *"tumor"* is a melanoma or not.

They are also used in **X-rays, Lab Tests, CT-Scans,** in this way mundane tasks can be carried out faster, more efficiently and accurately. For example, at present in Cardiology part of the patient data is monitored; heart-beat, blood pressure, and the oxygen concentration in the blood. Nevertheless, it is about being able to continuously monitor the rate and the depth of breathing, the brain waves, the activity, the mood of the patient at any moment and this can be accomplished by the whole implementation of AI in medicine.

However, researchers and scientists use artificial intelligence for **drug development**. That is an important achievement since getting an effective drug can cost billions and more than a decade.

In short, there are many benefits that artificial intelligence can bring us and if we let it in we will enjoy even more of its functionalities. Now, I would like to inform you more about the application of AI in vaccines and pharmaceuticals as, nowadays, we need a lot of support in these two departments and I am sure you will see the potential that AI can bring to our society.

5.6.2 AI IN VACCINES & DRUGS

Our health system has been transformed due to the wide range of circumstances that human beings have lived in, in the past decades. This has made the European Union a global leader in health-related to artificial intelligence applications.

Thus, it needs a high-standard health system with rich health data, and obviously, the promotion of a strong ecosystem of innovation in each of our countries.

In the Ebola epidemic, the power of an AI program was used to find from existing drugs the one which would be effective to combat the disease. In one day, AI had already found two drugs that could reduce Ebola infectivity. Without that program, the analysis would have cost months or even years.

With the pandemic of COVID-19, the AI's trend has drastically been accelerated since researchers have created many applications for contact-tracing the people who have been in contact with a positive of COVID-19. In this way, these apps monitor the spread of the virus and also reinforce the public health response to it by reducing the contagiousness of the virus and ensuring better health for society.

5.6.3 AI MEDICAL APPLICATIONS OF TOMORROW

Technology & artificial intelligence are rapidly evolving into real solutions for our health, and their power can definitely change our lives. However, all this potential will not serve if humans do not trust in it to our benefit. That is why we need to gradually incorporate AI techniques into our healthcare system that could save lives in many ways.

In the future, it is believed that with artificial intelligence and technology we can see any part of the body and make a three-dimensional image to view in 360º what is happening in any part of our organism.

In addition, with 3D printers, biomedical engineers will be able to print organs; thus, people in urgent need of a transplant will not be so dependent on a compatible patient and these engineers could even print a 100% compatible organ using the patient's cells, making incompatibility impossible.

In the field of cancer, improvements such as nanosensors are expected, which would enable cancer to be detected as early as possible. Notwithstanding, nanosensors may also be useful in detecting an impending heart attack or a forthcoming autoimmune attack.

Finally, it is also hoped that DNA seqüencing can supplant the traditional physical autopsy, as it can determine the cause of the death more accurately than the other.

All of these applications can be undertaken as long as biosensors, genome sequencing, and imaging are in our lives. For this, humans must give artificial intelligence a chance. Are we ready for this?

6.0 AI & MEDICINE

6.1 AI & MEDICAL DIAGNOSIS

I feel excited about the future, about the power of using the technological tools that we are immersed in. Everything in our decade is about the power to improve our quality of life, the power to save the planet we live in, and the power to improve, obviously, medical diagnosis.

Nowadays, we are surrounded by a lot of information that can plow huge datasets and learn within the process. In addition to the artificial intelligence techniques, deep learning will bring precision to diagnosis and even prognostication!

As I have said before, these tools are not created to replace humans but to improve and facilitate our daily lives by providing recommendations on the patients' treatment which will probably be the most accurate ever.

A physician of Ancient Greece called Hippocrates stated that "*It is more important to know what sort of person has a disease than to know what sort of disease a person has*." With computers, this can be easily achieved as they make patterns to give outputs just as we eat every day to survive. We should take advantage of it!

6.1.1 HOW DO PHYSICIANS DIAGNOSE?

According to Daniel Kahneman, "*To be a good diagnostician, a physician needs to acquire a large set of labels for diseases, each of which binds an idea of the illness and its symptoms, possible antecedents and causes, possible developments and consequences, and possible interventions to cure or mitigate the illness."*

Daniel Kahneman[23] is a Professor of Psychology at the University of Princeton. In 2002, he received the Nobel Memorial Prize for Economic Sciences. He has written many books such as *"Thinking, fast and slow"*, *"Noise"*, *"Heuristic and Biases"* among others. In some of his books, he has analyzed the process of how physicians diagnose and even has advised them to change the paradigm.

In real life time, when physicians assess cases, they need to process each bias of information as symptoms, test results and quickly come up with a wide range of possible causes that could fit with all these signals.

Daniel Kahneman would classify our thinking within two systems. Both occur in different areas of the brain and even differ from the metabolic requirements!

[23] Biography of Daniel Kahneman

On one hand, system one is that automatic, quick, intuitive and effortless way of thinking[24]. This system promotes rapid solutions to a problem. However, it has been demonstrated that using only system one is malfunctioning; it is also called fast medicine.

Donald Redelmeier, a Canadian physician who was inspired by Daniel Kahneman, and Amos Tversky, who was an Israeli psychologist who discovered the systematic human cognitive bias and handling of risk, wrote "*You need to be so careful when there is one simple diagnosis that instantly pops into your mind that beautifully explains everything all at once. That is when you need to stop and check your thinking."*

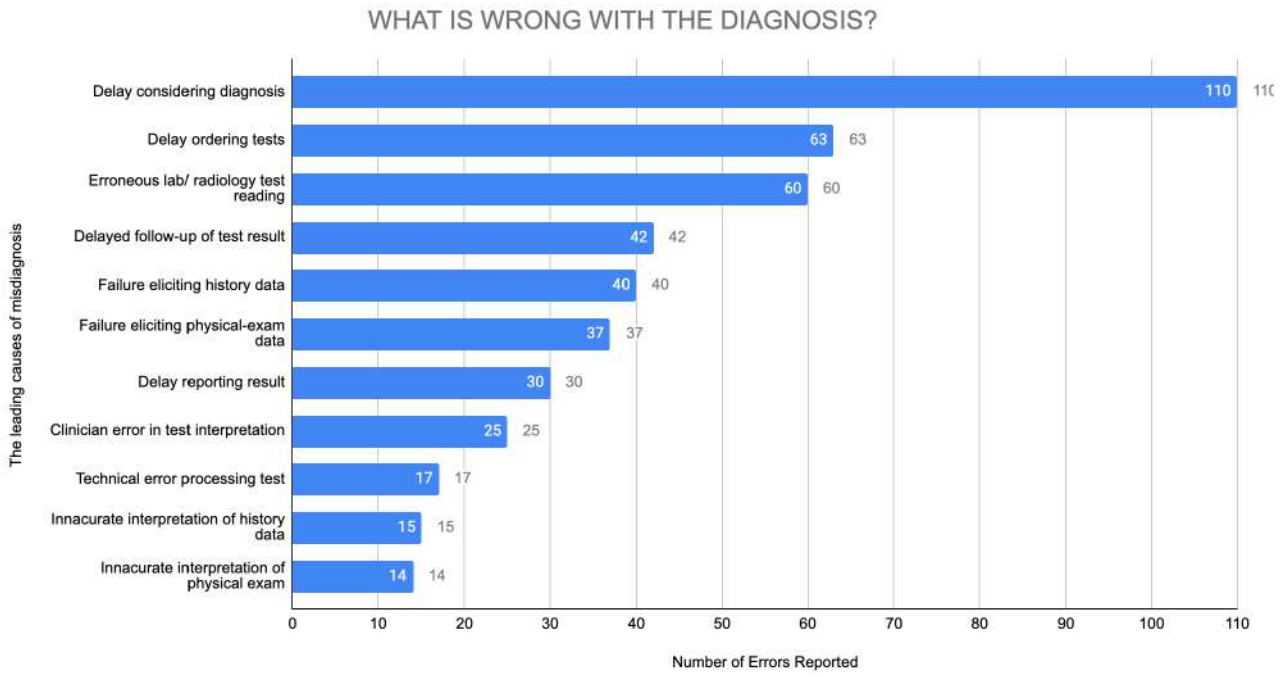
On the other hand, system two, in contrast, is a slow, reflective process that involves analytic effort. Notwithstanding, only using this system is not enough either.

That is why a mix of both is a better combination to provide the right diagnosis but there are other variables that come into play as well! One of these is the lack of empathy which is already happening at the medical school! In this way, doctors do not apply empathy to their work even if this one is a key factor for improving diagnostic skills and diagnosing correctly. We need to remember that each medical decision has a consequence on the patient's life!

6.1.2 WHAT IS WRONG WITH THE DIAGNOSIS?

According to the Wall Street Journal[25], the leading causes of misdiagnoses in a sample of 583 physician-reported cases are the following in the graph:

[24] Judgement Under Uncertainty: Heuristics and Biases.
[25] "The Key to Reducing Doctors' Misdiagnoses"



[26]

As we can see in the chart, delay in diagnosis is the most important reason for malpractice leading to misdiagnosis in close to 19%!

What I pretended with this chart is to demonstrate that physicians are not perfect since they are humans and that is why they make mistakes. Unfortunately, these mistakes in this profession can cost lives!

However, I cannot prove my theory based on the error rate between physicians and machines, since in today's medicine, artificial intelligence is not practiced when it involves the patient. My question now is how can we know if something is good or bad for us if we do not even test it in our medical system?

From my point of view, I think that artificial intelligence should be implemented gradually. If we see that it helps the medicine to achieve better results, let's move forward. If it does not, let's eliminate it; but I am sure this will not happen.

[26] Figure 4: Causes for misdiagnosis. (self-made)

So, we could take advantage of computers and programs which are more efficient and they do not depend on fatigue, great or horrible days, our mood or simply life circumstances. They operate based on a program that humans have created to ensure efficiency and perfection in the execution of the area in which they are engaged.

In healthcare, AI techniques in computers and programs can be perfectly applied since, in comparison to a doctor who might visit around ten of thousands of patients, they are able to amass by data collection, the 700,000 physicians' expertise, or even several million worldwide!

However, nothing is as simple as it seems and diagnosing with AI is complicated since each patient has a different organism with subjective symptoms and how they are differently described by each patient. In the same way, the gestures and the facial expression also varies among patients.

All of these turn diagnosing into a difficult practice for AI's world since it is so complicated to capture in a few words all of the many stimuli that are in our body when in pain.

The Human Diagnosis Project[27] is a worldwide community of medical professionals dedicated to ending unequal access to medical knowledge. It is used by more than 6,000 doctors that come from around 40 countries. Its purpose is to create a community of contributors that can share medical cases and receive feedback from them, helping physicians with their clinical reasoning and elaborating the proper diagnosis for patients.
To achieve this relationship by communicating diagnoses among great doctors, it is necessary to combine collective intelligence, which comes from physicians, with machine learning. This project pretends to be more accurate and affordable in the future; in this way, all the countries of the world will have access to medical knowledge and not only a few.

[27] The Human Diagnosis Project

By the way, this company intends to levy at least 100,000 doctors at the end of 2022 and even increase the use of natural-language processing algorithms to combine AI tools with all of the doctors that contribute to this amazing project!

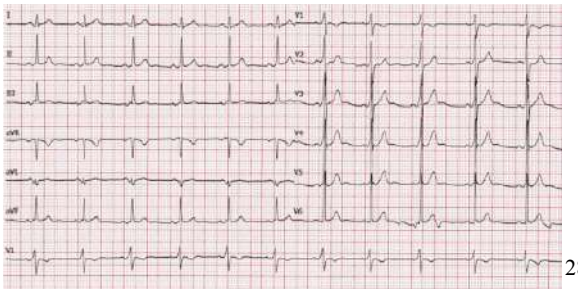
6.1.3 WHAT DOES AI DO FOR DIAGNOSIS?

I think that it is important to note what AI has done for diagnosis until now. Many applications and tools have been created to ensure substantial progress in the field. Many of these are related to the diagnosis of different parts of the body.

According to Eric Topol in his book *"Deep Medicine,"* there are three main areas in which AI has made a difference in the last few decades; the brain and the heart which are vital for human beings and cancer!

In the brain, AI has achieved better interpretations of medical scans for those who may have a stroke thanks to reliable brain images, which have also improved the diagnosis of Alzheimer's disease!

In heart research, AI has accomplished its goals of improving not only electrocardiograms, which are the records of a person's heartbeat well represented in figure 28, for arrhythmias, but also on echocardiographic images which are a type of medical test that uses sound waves to capture live images from your heart, well defined in figure 29.



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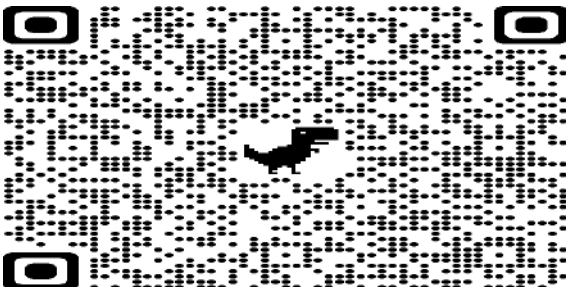


[29]

[28] Figure 5: Electrocardiographic Image

[29] Figure 6: Echocardiographic Image

In cancer, machines have diagnosed skin lesions as well as many eye diseases thanks to the retinal images since they are so accurate. In addition, it has been demonstrated that processing sounds and voices have improved the diagnosis of many types of stress disorders or even traumatic brain injuries.

However, not only machines have been created to improve diagnosis but also applications such as the Face2Gene app which help the diagnosis for more than 4,000 genetic conditions. This app increases the confidence of clinicians and bioinformatics by prioritizing genetic disorders and variants in clinic and in the lab.

The creators of the app have accomplished this goal by applying deep learning to images of people, identifying facial features that are landmarks of the syndrome.

This continuously favors the diagnosis of genetic and rare diseases and the best thing of all of this is that the machinery needed to apply AI and improve diagnosis is relatively cheap and fast. That is why this fact could make the treatments more cost-effective.

6.2 AI & MONITORING PATIENTS

Establishing a monitoring patient system is not difficult if the measurements require low frequency of data since if there is a high frequency of information, it requires paying more attention to the structure of the system.

Notwithstanding, the real difficulty relies on the collaboration of healthcare professionals that we don’t have so much, and obviously of the patients to ensure that they are being monitored properly by the AI program.

In addition to all of this data that is being requested, there must be some ways of communication between the patient and the hospital and its professionals to share the symptoms that the patient has experienced, for example.

6.2.1 WHY IS PATIENT FOLLOW-UP NOT A SUCCESS?

To develop a final product, a process design must be followed. One of its steps is called *"Test and redesign."* This step consists of testing the implementation and seeing if the requirements are being fulfilled.

However, to achieve this you need to have many healthcare professionals to review data, clinical evidence, a proven solution as well as a great economic potential to support all of these challenges and commercial costs.

Now, let's talk one by one to get the whole understanding of them.

The first reason that I would like to comment about is the **lack of healthcare professionals** since the results and its improvements of any health system could only be achieved by monitoring patients' data. But to ensure that the AI program works, we need healthcare professionals who review the results and act on them. I know that they are expensive and have a short supply but they are a mandatory requirement for the success of the product.

The second reason is related to **clinical evidence**[30] which implies that a system has **improved results** since patients have been monitored frequently and well; **improved comfort** because the patient has required no need of going to the hospital to make measurements but staying comfortably at home doing them and, finally, when there is clinical evidence there has been an **improvement in the efficiency** of the system as the time needed to process a patient is reduced; consequently, doctors have more time to focus on those patients that demand special attention due to the workflow of automation.

The last reason is the **lack of a solution.** This motive is due to different ways of thinking among engineers and healthcare professionals. Engineers have been taught during all their career to seek the cheapest, efficient and practical product. However, in the world of medicine, these are not the standard requirements but doctors and other healthcare companies look for a solution for

[30] The Future of Remote Patient Monitoring is in Artificial Intelligence

treating a specific type of disease or a platform that enables patients to follow a standard care protocol.

In summary, to achieve a successful patient follow-up, our system needs more healthcare professionals capable of effectively monitoring patient data, as well as an understanding between the reasoning of the engineers and that of healthcare professionals.

6.2.2 THE PROMISE OF AI

AI is our promise for a better future in healthcare. It is expected to cover the monitoring of the patients but also the disease management!

In the monitoring process, the AI program could identify patients, by analyzing data, that may need potential attention. In this way, due to the automation process of AI algorithms and systems, doctors would have at their disposal more time to dedicate to those who need care.

The main goal of artificial intelligence is, however, the management of all patients' treatment in the way that is expected. This will function while the patient is being monitored. When the system detects something wrong in his organism, the patient will receive feedback with the treatment that needs to be followed. In this way, only when the treatment does not function or exceeds the limits set by the doctors, will healthcare professionals intervene.

It should be noted that at all times, there will be healthcare data analysts that will review all the responses the AI systems provide to the patients. In this way, safety will be guaranteed.

To conclude, I strongly believe that AI is such a promise to help solve the healthcare crisis that we are facing nowadays. Through AI, we have the power to radically improve the way we live. I am aware that it is an expensive investment at the beginning but I believe that it will be so rewarding in the end! In a few years, thanks to artificial intelligence we will free doctors from routine

and mundane tasks and we will evolve from monitoring patients to disease management with the AI power!

6.3 AI & PERSONALIZED HEALTHCARE

The world that people live in today is full of personalized entertainment. The fact that we are giving likes on social media, watching some videos on Youtube, and buying certain types of clothes generates an incredible amount of data with which AI is relatively easy to manage. Artificial Intelligence allows humans to establish clear characteristics about a person by analyzing their data.

In healthcare, the same is happening as in music and even on TV platforms such as Netflix. Clinicians and pharmaceuticals are looking at this data, to get an idea of how the patient is and how he or she will respond to the treatment. They are trying to develop personalized treatments and therapies to achieve their goal in an ideal life; prevent disease.

Nevertheless, there are many variables in treatment and it needs a large amount of data and many insights from each patient. But no worries since with AI, all of this is possible since it is capable of managing huge datasets!

These datasets contain genetic and genomic data of the patient, his medical history; everything a doctor should know and consider to prescribe a drug or a treatment to any patient. Thus, AI through machine learning models could find patterns, trends, and anomalies in data that simply inform the doctor of these anomalies to prevent the patient from disease. So, with AI in the background, doctors will make better and informed decisions.

6.3.1 GENERIC VS. PERSONALIZED DRUG DEVELOPMENT

Unfortunately, nowadays there are many clinical trials, which are tests that examine a patient or something like a machine to ensure its good performance, that are still executed by giving the same dose of a drug to people that,

obviously, have different genetics and specific biomarkers on their body[31]. The result of this trial is how the majority has reacted.

However, what happens to those that are not within the statistical approach? The answer in generic drug development is that those patients won't have the drug efficacy on the treatment that the others will have.

Contrarily to those patients that are on personalized medicine, if the standard treatment does not work for them, physicians through physical, genomic, and genetic exams will find the best treatments and therapies for the patient benefit and not for the population benefit. AI will help to achieve them, giving velocity, volume, variety, and veracity to the process!

What you may ask yourself, which are the procedures in both types of drug development? Well, I think it is important to explain both so that you can see the differences between them. Let's begin with **generic drug development**.

6.3.2 GENERIC DRUG DEVELOPMENT

According to the standard phases of generic drug development, I would divide this process into five steps[32]:

In this first step, the main goal is to ***"Find all the Targets"***, which are the genes and the proteins that play a relevant goal in a disease. Once they are found, they can be useful as drugs since they often meet the commercial requirements. However, before being ready to consume, assays are required to find the compound that will form the drug, reduce its side effects and start the development of the same.

[31] The role of AI in advancing personalized healthcare

[32] Drug Discovery and Development Process

After this, begins what is called the ***"Preclinical Research"*** which is the step that determines the drug's efficacy and also its safety. In this phase is defined the correct dosage, the side effects on gender, race among others, and even the efficacy when this one interacts with other treatments. That is why I believe this is a crucial step to determine the competitive advantage in comparison to other drugs.

The third step is called ***"Clinical Development"*** in which researchers move to it the drug's development and even begin some studies and trials with human volunteers. Personally, I think that this phase is the most difficult and also controversial since there are many variables to consider such as the budget but also the efficacy and the reduced number of side effects that the drug must have on the volunteers that participate in these trials. This rigorous process must be followed correctly and if we want to be effective, it needs as many volunteers as possible.

After making many trials on volunteers, analyzing biological samples, and ensuring the patients' safety in its consumption, the next phase consists of reviewing the drug. This one is executed in the US by the FDA, which means Food and Drug Administration, and by the EMA in Europe, which means Agencia Europea de Medicamentos.

There are many reasons why a drug can not be approved by these administrations. Some examples would be the **toxicity** since the chemical substance should not damage the organism; another reason is the **lack of efficacy** of the drug which provokes a rejection by the FDA or the EMA and even the **incoherent response of a drug** because if it does not fulfill the desired function, what is it good for?

Finally, the last phase is the **monitoring of the drug** after its launch on the market since in this follow-up, patients or manufacturers can report any problems that they may have and this guarantees the safety of society.

6.3.3 PERSONALIZED MEDICINE

In personalized medicine[33]genetic, genomic, biomarker studies, and a physical exam are the first things that are performed on a patient to **establish a diagnosis** and define the treatment and its best dosage; that is why this will be called Phase 0.

This is followed by the **study of pathobiology**, which is a branch of medicine that focuses especially on the changes that occur in the organs and tissues of the body due to or caused by the disease it is suffering from. In this phase 1, clinical trials are initiated but there are not so many volunteers but only a few. This fact ensures high sensitivity to the effects of the proposed drug and consequently, careful monitoring of those who enrolled in the trial is needed.

Phase 2 is what is called the **Intervention Choice** and it consists of taking action to implement a treatment or a therapy to an individual. This is not as easy as it seems since two circumstances can occur here. If the patient needs an existent drug, then perfect, the choice would be based on matching the patient's profile with the action of a drug. However, if the available drugs do not fit with the patient's needs, then through biopsies and biomaterials, researchers could develop a personalized drug that could save the patient's life.

After that, phase 3 is what is called **Intervention Testing** which involves checking if the intervention choice has worked on the relevant individual undergoing the diagnosis and pathobiology assessment.

Finally, the last one is called **Data Warehousing the Results** which implies storing all the patient data and the information obtained so that the patient data could be analyzed to find further patterns and conclusions between lifestyles and illnesses.

6.3.4 THE KEY INGREDIENT; AI

[33] Artificial Intelligence and Personalized Medicine

AI plays a great role in the designing of new drugs. Its application has been used in many design situations, from materials optimization, where the main goal is to get the best version of a material based on its properties, to find the best way that these materials can be packaged into one, so what AI does here is to identify the best structure into which all the materials would best fit.

In addition, with AI, large huge datasets can be collected and analyzed with the machine learning capabilities in such a faster way than if it was done manually.

Furthermore, artificial intelligence provides a clear vision of the data since it is capable of creating patterns among a group of patients with certain characteristics which allows humans to know information that we would not be able to relate to.

If the data is analyzed more quickly, therapies and treatments will be developed rapidly. This fact makes AI able to administer dosages to the patients' treatment and even to prevent disease since having more information about what has provoked a disease will make humans more conscious about it and we will be able to introduce prevention measures.

To sum up, AI is the key that will open the door to personalized medicine. It will introduce velocity, accuracy but also veracity in our healthcare system. Definitely, artificial intelligence will facilitate drug discovery, predicting the right dose to a patient. This dose depends on so many variables such as gender, race, weight among others and that is the perfect task for such a deep learning algorithm! Our goal in an ideal life is to prevent disease; so what are we waiting for?

6.4 AI & THE VIRTUAL MEDICAL SIRI

6.4.1 THE STORY OF DAVID & THOMAS

- David, I have a pain in my gut!
- What and when did you eat last, Thomas? -said the virtual medical David.
- Well, around two hours ago. But I am not hungry David.

- Ok, I will schedule some tests. Don’t worry, I will order the kit for the blood test, and meanwhile, could you get your smartphone ultrasound? We'll have the results of the tests on Wednesday.
- Well, the ultrasound is all right. The images are clear and do not show any anomaly.
- Thank you, David. Could I take something for the pain until Wednesday?
- Yes, you can take a stomach protector before meals and a low-carb diet.
- Perfect, thanks!
- Your welcome, Thomas.

Wednesday

- Thomas, I have your tests’ data to review.
- Ok, David. What do they show?
- Thomas, there is a bacterium called S. fecalis. The presence of it increases the risk of colon cancer. I need to make sure that it is only a bacterium and not cancer. I want you to have a colonoscopy.
- Ok, thanks, David.
- Don’t you worry about it Thomas, I am sure whatever this is has been caught in time.

The End

6.4.2 ISSUES WITH THE VIRTUAL MEDICAL SIRI OF THE FUTURE

After reading this story, it is easy to fantasize about the idea of having a virtual medical Siri to take care of us and improve our health. However, there are some issues related to this dream that I want to show you since building it is not so easy because of the simple fact of what it represents for the society we live in as well as for the whole world.

Creating a powerful, virtual medical Siri is a multi-faceted challenge that includes both political and technological issues. However, its creation would

involve not only growing physicians but also helping us to take care of ourselves and be our best version.

The virtual medical Siri needs so many inputs to be as good as a doctor or even better since it can have the data of 7,000,000 doctors and healthcare professionals together which implies so much knowledge that can be applied to all the patients.

Notwithstanding, everything is not as pretty as it seems and this is one of the cases. This machine to work properly will need to know our medical history but not a part of this data but all the data. From the prenatal phase to the present, it needs to be continuously updated. This is a hard first step since it can be a life stress event because of its intrusion into people's private lives. The main point here is that the quality of the input data is essential and the lack of it would compromise the veracity of the output of the AI assistant. [34]

Another mishap would be related to poverty. If the medical Siri is improved in results and reduced in costs, a citizen with a salary in which can afford it will definitely want to buy it. By enabling these devices to be purchased, inequalities in health care would be further addressed. Not to mention that in the undeveloped countries this technology would not arrive.

That is why I believe that this technology should not go beyond the hospitals as, in this way, medical inequalities between countries would be avoided, and consequently, the creation of many medical Siris in the hospital would be favored. For example, one or two in each hospital could be a great idea as there are departments that in their day-to-day work face very important decisions; for that, a medical Siri would support the veracity of a doctor's decisions or perhaps simply provide objective reasoning based on the data obtained and give the physician another view.

However, the world we live in does not think about the consequences that this device would have on emerging or underdeveloped countries since large companies and even young entrepreneurs would think that even if they had that,

[34] Deep Medicine: how Artificial Intelligence can make healthcare human again

they would not have the necessary tools to give to them the cure for a disease. Thus, we are at this point, even though the world is not the same, the mentality remains so identical. I am aware that perfect equality can never be achieved, but what would happen if we balanced the scales of healthcare a little bit? We all deserve a life, or rather, a quality of life, don't we?

6.5 REBUILDING THE VALUES ON HEALTHCARE

"In learning to talk to his patients, the doctor may talk himself back into loving his work. He has little to lose and much to gain by letting the sick man into his heart." - Anatole Broyard

Anatole Broyard[35] was an American writer, literary critic, and editor from New Orleans who wrote for The New York Times. In addition to his many reviews and columns, he published short stories, essays, and two books during his lifetime.

These words made me return back to a moment when I was watching TV at night with my parents; they were asleep but I was clear-headed so I kept watching it. The news of February 27, 2020 was being televised and I will never forget the day when the BOE, which means *"Boletín Oficial del Estado,"* published the new regulation that implied only 20 minutes per visit for doctors.

That day I couldn't understand why medicine was treated as a commercial company. The key words they were talking about in their speeches were productivity, efficiency among others. Pardon? In which world could you establish the necessary and standard time in which you could diagnose without being wrong in your decisions and making the necessary to save the life of a patient? The answer is none.

Since then, I understood that our society needed a solution with the *"time"* which is a factor that has been trimmed due to the explosive economic growth of healthcare over years. This fact provokes the most of the worst consequences to medicine, being dehumanized.

[35] Biography of Anatole Broyard

Since this regulation, medicine has moved even further into an era of error, waste and poor outcomes that already existed then but is even more present now.

Statistical data shows that more than half of doctors suffer depression[36] and there are three hundred to four hundred physician suicides[37]each year in the United States. If this is the data, something is wrong, don't you think?

Time is a key factor for establishing relationships with people and even more for a doctor who treats unknown people every hour. The main point here is that without time, human-to-human bonding is not possible, and if the doctors don't have this relationship with the patient, the consequences will be devastating as the doctor will misdiagnose the patient or feel that he or she is not fulfilling his/her vocation but rather only visiting hours, which will cause him/her distress in life.

The National Bureau of Economic Research published a paper in 2018 by Elena "A"yeva and her team at the University of Pennsylvania that studied the effect of the length of home health visits for patients who had been discharged from hospitals after treatment. It was based on more than 60,000 visits by clinicians and they concluded that every extra minute that a visit lasts, there was a reduction in the risk of readmission to the hospital of 8%[38].

So, this study demonstrates that time can make the healthcare system save money by not having to hospitalize people unnecessarily because with enough time and without the pressure to keep to a schedule it was possible to make a good diagnosis that showed that there was no need for hospitalization. The outcomes on healthcare are directly related to time!

[36] Doctors have Alarming High Rates of Depression
[37] Doctors Reckon with High Rate of Suicide in Their Ranks
[38] Association between Dietary Factors and Mortality from Heart Disease, Stroke, and type 2 Diabetes in the United States.

Here is when AI appears; to solve all the problems caused by the *"time"* and unleash the human power of empathy. Now, we are going to talk more deeply about this but don't forget that AI is going to revolutionize medicine!

6.5.1 THE GIFT OF AI: TIME

In the USA, the stipulated time of a visit is twelve minutes and if it is a return visit, it will be seven minutes long! Incredibly, isn't it? However, we have the luck to have artificial intelligence in our lives since it is our time giver!

While physicians spend at least two-thirds of the visit time collecting electronic medical records, patients get bored during the visit and may think a lot during 12 minutes from what they can eat when they arrive home to asking themselves *"What's my business here?"* Note: The physician would not even notice, he would be writing on the screen. And that is precisely the problem!!

When physicians finish writing on the computer, they have five minutes left to do the physical exam and make the diagnosis. Do you think that is enough? I don't.

Many people understand productivity as seeing more patients in less time. That is not the point! What we need to understand is that the purpose of physicians is not seeing more patients in less time but to save their lives! However, the regulation is still there and the way to accomplish it and reduce misdiagnosis or malpractice lies in the application of AI.

For you to understand how AI could take part in the healthcare system, in the recent future, I want to tell you a brief story.

" David is our medical AI assistant as in the last story, do you remember? He will collect and analyze all the data provided by the patient, but will also take into account the patient's medical history to make a good diagnosis. Meanwhile, the doctor will listen carefully to the patient and make sure that he/she is understood. In addition, with eye contact, the physician will relax the patient who is worried about his heart."

- *Good morning Martin! -says the doctor.*
- *Good morning Dr. Medina. I am worried about my heart.*
- *Tell me about it.*
- *Well, I was talking with my wife last Friday when suddenly, I felt a big pressure in my heart. I was so terrified and I was only able to sit on the sofa.*
- *Ok. Is there anything else that you want to share with me?*
- *Well, my wife and I weren't talking but arguing and I was getting nervous. But I eat well and healthy and I have no cholesterol; I don't understand what has happened to my heart.*
- *Don't worry Martin. We will find the cause. Now, I'll make you a physical exam, is that OK?*
- *Of course Dr. Medina. Thank you!*

"While the doctor and the patient were conversing and bonding, David, the medical assistant, was collecting data. In this way, together with Dr. Medina will make a great diagnosis to Martin."

This is such an example of how AI could be applied. The figure of the physician is fundamental not because of his or her knowledge, but because of his or her humanity. Empathy is what characterizes our humanism; connecting with the patient and his circumstances and working to find a way to save him is the path we must follow to make healthcare human again. We have proven that AI gives us time to be human in our work and reinforces the doctor's decisions; what are we waiting for to implement it?

6.5.2 BEING PRESENT

Abraham Verghese is an American physician, author of three best-selling books, Professor for the Theory and Practice of Medicine at Stanford University Medical School and Senior Associate Chair of the Department of Internal Medicine. He states that*"Being present is essential to the well-being of both patients and caregivers, and it is fundamental to establish trust in all human interactions."* He is such a medical pearl!

So far we have talked about empathy, but empathy is not enough to re-establish the doctor-patient relationship. There are many fundamental factors in establishing a bond in interactions and one example is **presence**, which is the art and science of human connection and it predicates the quality of healthcare.[39]

William Osler, a Canadian physician who was also one of the founders of Johns Hopkins Hospital and the creator of the first training program for physicians, simply said: *"Listen to your patient; he is telling you the diagnosis."* To listen carefully to make the right interpretation, a physician must be present since even though AI manages to synthesize or analyze data, it will never be able to interact in the way that a person would.

That is why doctors are essential, since making the diagnosis not only involves data but the patient's feelings and those words that are between the lines. These can only be heard when physicians are present.

Last week, I read something in JAMA, which acronym means the Journal of the American Medical Association, related to a new trend in some medical centers that awaited me. It said that in some hospitals or private consults, physicians give a card to their patients that contain a picture of him or her and personal information about their interests or their hobbies.

Following this path, physicians are making the first step to start a trusting relationship with their patients; and in this way, my friends, the ice breaks and malpractice and misdiagnoses are reduced.

6.5.3 BEING AN OBSERVER

The fact of being present is not enough either if you want to make the right diagnosis to a patient; you will need observational skills.

[39] Presence: The Art & Science of Human Connection

Some years ago, the University of Yale announced that the students needed to learn the art of observation; that is why the professors thought that visiting art museums would be a great way to improve their skills. [40]

These classes consisted of six 90-minutes sessions in which students could practice, improve and develop their observational skills. But you may ask yourself, why are these skills so important?

The answer is so varied, as having observational skills provides the physician with an immediate overview of the patient's problem which is very valuable.

However, the best of these skills lie in the role they play in the physical examination. Medicine is evolving to getting out of touch with the patient, and *"time"* can be one of the multiple reasons.

But through these skills, we seek to promote the essence of what makes us human, which is contact. Without it, a diagnosis is incomplete!

AI can improve many aspects of medicine; one example is giving time to restore the patient-doctor relationship. Giving time involves a physical examination, exclusive attention to the patient, and enjoying the vocation of being a doctor saving people's lives but also healing their heart. Now, let's go deep into the fundamental basis for a cherished relationship between the doctor and the patient.

6.5.4 RESTORING THE PATIENT-DOCTOR RELATIONSHIP

Empathy, presence, observation, listening, communication, the laying of hands, and the physical exam are the fundamental blocks to build real medicine which will consequently improve people's life.

These humanism interactions are not easy to quantify or digitize as all of them are emotional and personal in nature. In addition, they depend exclusively on

[40] How Looking at Paintings Became a Required Course in Medical School

the trust that a doctor and a patient can bond with each other. That is why a doctor is essential to medicine and cannot be replaced by machines.

Notwithstanding, medical school doctors are trained to keep an emotional distance from their patients, which in my opinion is not the path to follow. They are disease-oriented rather than humanism-oriented; that is why, current physicians do not heal patients but cure them.

Now, I am going to explain the difference between these two terms in a simple example: "*Imagine that you go away for a week and when you come back, some squatters have occupied your house. Your house has an alarm so you call the police and they tell you they will take care of the situation. The next day, they call you back and say that you can return to your home. But when you arrive at your home, you are only partly restored; you are "cured" but not "healed" since your sense of violation remains.*"

Eric Topol, who is an American cardiologist, author and scientist, in his book Deep Medicine wrote: "*When there is a genuine, deep patient-physician relationship, healing comes easily and naturally. Patients will then believe doctors who say they will be there to support them, whatever it takes*." But, nowadays, this is very difficult to find; therefore, the way medicine is taught today must be renewed and emotional intelligence must have priority when choosing doctors, as these will be the qualities most needed in a future for which there is not much time left.

Future doctors will need a far better knowledge about bioinformatics, biocomputing, deep learning, neural networks and so on. As many of their decisions will be supported by algorithms, they need to understand all the duties. However, medical schools are unprepared for these inevitable challenges because the curriculum relies on the University which tends to resist the changes. According to Haider Javed Warraich, who is a Duke Medicine trainee, *"Young doctors are ready to make health care both innovative and patient-centric. But are the senior doctors they work with, and the patients they take care of, ready for them?"*

So I can understand that if doctors are not taught emotional intelligence in medical school, young doctors might find it difficult to interact with strangers every day.

Nevertheless, sick patients are mostly in a state of vulnerability and need for trust, and to be open, physicians should implement the fundamental basis we discussed earlier.

However, when the medical students arrive at hospitals, they are confronted with reality, which does not require distance from patients but closeness to them.

Proximity is a key factor to communication between patients and doctors since unfortunately, many doctors need to deliver bad news, and, in these circumstances, physicians have a guide to follow called SPIKES: setting, a patient in a quiet and private room; patient perspective, understanding the situation; information, how much the patients and family want to know; knowledge, letting the patient speak first after delivering the news; emphasize; and, finally, strategize next steps[41].

All these requirements make it clear that communication cannot, under any circumstance, be delegated to algorithms as patients need humanism, and this will come from physicians.

6.6 AI & PRIVACY & HACKING

Over the years, the term of privacy[42] has increased in value and is gradually under close examination due to the transformation it has undergone with technology. I think that the concept of privacy is moving, relying on the period in. That is why, nowadays, our expectations with privacy have changed in the same way as the basic standards of it; basically, we live in a different way.

[41] How Doctors Deliver Bad News?
[42] The (Evolving) World of AI Privacy and Data Security

According to Eliano Marques who is an executive VP of Data and AI at Protegrity, which is a company that specializes in privacy and data protection of well-established companies, states that ten years ago hackers were only attached to raw data. However, today, they are able to extract information that has been memorized by any type of a machine learning model as Neural Networks which allow them to take advantage of data that was supposedly secure.

I strongly believe that the key to ensure privacy to us is on the awareness of what data is being requested on a certain web. In addition to the right that we have to modify our personal privacy settings to ensure that the requirements fit our intentions .

In the era of hacking, all operations using AI need to learn about their threats such as bad data that corrupts their systems, AI malware and so on.

6.6.1 RISKS OF AI & DATA PRIVACY TO SOCIETY

As Shree Das states in his article "*The Social Impact of Artificial Intelligence and Data Privacy Issues"*[43]*, "The current era of AI and Big Data is already considered by many as the start of the fourth industrial revolution that will reshape the world in years to come."* But my question is: will technology cause irreparable damage to society's privacy?

It is true that technology is putting society at risk since many organizations are collecting and processing data and using it without the knowledge of society which will bring social consequences.

People are becoming increasingly aware that their data is not safe online. Notwithstanding, most of them still do not realize the gravity of the situation when AI-based systems process their social data in an unethical manner.

That is why my intention now is to make you aware of some risks that you may be exposed to online through some scandals that have occurred in the last decade.

[43] The Social Impact of Artificial Intelligence and Data Privacy Issues

Let’s begin with **Cambridge Analytica** which was a firm that was sold data from users of Facebook. Although this can sound a little bit rare, Facebook did not sell users’ data but a developer who created a quiz. While users were playing it, they were agreeing to share all their data and also that of their friends! All of this without the user's knowledge!

Thus, all the data collected and processed was used to predict who would win the elections but also to know who each user voted for!! I think that is unbelievable!

Another case is in **China** with **mass surveillance** without the consent of the citizens. It is based on an AI program that rates the trustworthiness of its citizens and if you have a high credit of reliability you will receive more than those who have less. But the worst of all of this is that this system has been applied without the consent of Chinese people!

Finally, the last case we will talk about is accomplished by using Deep Learning and it is called **Deepfake** since this program uses an image of a person to paste it into a video that says something that in real life this person has not really done or said.

In 2019, an application called Deepnude was created. It consisted of uploading an image of a woman and this application would fit it in a way that would really look like a real nude image of the woman you choose for! This app allowed users to exploit women without their consent and even share these pictures on social media!

To sum up, we have seen some aspects that make us doubt the reliability of these technologies. But as all things in life that raise concerns on people, AI is not an exception. AI is basically borning in our decade and our obligation is to ensure that it prospers and grows in the best way achievable and contributes to improving our society and not damaging it.

7.0 PRACTICAL PART - KNN ALGORITHM

7.1 INTRODUCTION

It all started with reading other research papers. I saw that the possibility of doing a practical part of the work was very exciting for me since it meant being *"at the foot of the barrel"* and knowing what I was researching.

Thus, during the summer before high school I tried my luck in many laboratories to access the latest technology of large hospitals such as Bellvitge, the Clínic de Barcelona, the Quiron Teknon among others; however, either I received no response or they were negative due to the pandemic situation, very recent, that we lived then.

However, I continued to persist, this time in science parks and programs such as *"Argó"* of the Autonomous University of Barcelona; again I was not accepted because either the subject matter was not suitable or I was simply rejected.

My mother told me that I was very stubborn. Even knowing that the conditions of the Covid-19 limited me a lot, I kept looking for a way to get in touch with someone who could give me a hand with the practical part because I did not want to limit myself to surveys and interviews, I wanted to go a little further and know how to create a program in which artificial intelligence was applied.

So, it occurred to me to contact my teachers of the program, in which I participate every week, called Talent Jove of the URV. In this program we do

mathematics and physics, so my teachers could either help me or know someone who is an expert in the field. So, thanks to the physics teacher Mr. “F” I got in touch with Mr. “D”, a great expert and professional of the URV in artificial intelligence. Due to his great managerial responsibility, he could not provide me with his help although he offered me an interview in a possible future.

My persistence made me continue in all of this so I also asked the mathematics’ teacher Mr. “J”, he told me that he would talk about it with his department and he would tell me something. This time luck was on my side and I received great news: Dr. Dr. “x”, Ph.D. would be my tutor in the technical and practical aspects!

At the same time that I contacted my professors, an Instagram post from the UOC came into my hands. This one talked about a researcher, Agata Lapedriza, who was carrying out ambitious projects related to the subject of my Research Paper: applying AI to biology and to the medicine of today. I was so enthusiastic that I couldn't avoid contacting her and although she didn't answer me the first time, when I sent her the email again I finally received a great response, she was also willing to help me!

And I am currently at this point, ready to carry out a practical part that excites me but the best of all is that I have the necessary help to achieve this goal with great success. I thank, from the heart, both Dr. A.L, PhD. and Dr. “x”, Ph.D. for this support that they have offered me selflessly, but my tutor from the “school” , Mr. “M”, is not exempt. Thank you very much to all three of you!

Thankfully,

“A”

7.2 HYPOTHESIS

“Perhaps by applying artificial intelligence it is possible to create an algorithm capable of detecting breast cancer with a high degree of efficiency.”

7.3 GOAL

Designing a KNN algorithm capable of identifying through patient data whether it is a benign or malignant tumor in the case of breast cancer.

7.4 MATERIAL

To do the algorithm I have used:

- The UCI Machine Learning Repository.[44] [45] This database has many collections of databases, domain theories, and data generators that are used by the machine learning community for the empirical analysis of machine learning algorithms.[46]

  In my case, I used it because this database allowed me to properly calculate the distance of each attribute with respect to the test patient; in addition to providing me with reliable data and with objective ranges for each parameter.

- Excel, which is an application that has a multitude of utilities and many tools such as pivot tables, calculation functions and even a macro programming language to develop an algorithm, which is what I have done.

[44] Citation Requests UCI Data Breast Cancer Wisconsin
[45] Citation Requests UCI Data Immunotherapy
[46] UCI Machine Learning Repository

7.5 METHODOLOGY

To perform this part of the work, I developed the KNN algorithm by using excel. Both Dr. “x”, Ph.D., and I preferred to start and create a Breast Cancer Algorithm from scratch, instead of using a program already created and programmed on the Internet to see the results with Python, which is a specific programming language for developing artificial intelligence applications.

So, according to the current definition, an algorithm is a set of steps to be followed by a computer and that is what we have done. As I hadn't tried anything like that until then, first Dr. “x”, Ph.D., gave me some materials to read and then she explained to me what process we would follow.

Until the end of the algorithm, we met three times and when I had any type of problem we communicated through email; in this way, she could help me with it in an efficient and productive email.

Notwithstanding, when the difficulties I faced during the process required more than an email to be understood, Dr. “x”, Ph.D.without any problem organized a meeting on Teams and we solved it.

7.6 THE KNN BREAST CANCER ALGORITHM PROCEDURE THROUGH EXCEL

Until this project, I had used excel very few times and this scared me a little. However, I think that it is a great and multidisciplinary application in which you can develop great things such as an algorithm!

Now I am going to explain to you through steps the process I have followed in order to achieve my goal but also the problems I have gone through in its creation and the solutions we, Dr. “x”, Ph.D.and I, have come to.

First of all, I needed to separate the data set into a training set and testing set, most of the data is used for training and the testing data is used to test the model by making predictions against the testing data.

So, I decided to use as training data group 8 of the total data, because this is the most recent group and I would avoid one of the most problematic obstacles, the repetitions on the IDs of the patients; later, in point 6.3, I will delve into this matter that I faced during the development of the algorithm.

ID	ESPESSOR DE	MIDA CEL·LUL	FORMA DE LA	ADHESIÓ	MIDA EPITELI	NUCLI	CROMATINA	NUCLÈOLS	NO MITOSIS	CLASSE
1016634	2	3	1	1	2	1	2	1	1	2
1031608	2	1	1	1	1	1	2	1	1	2
1041043	4	1	3	1	2	1	2	1	1	2
1042252	3	1	1	1	2	1	2	1	1	2
1061990	4	1	1	1	2	1	2	1	1	2
1073836	5	1	1	1	2	1	2	1	1	2
1083817	3	1	1	1	2	1	2	1	1	2
1096352	6	3	3	3	3	2	6	1	1	2
1140597	7	1	2	3	2	1	2	1	1	2
1149548	1	1	1	1	2	1	1	1	1	2
1174009	5	1	1	2	1	1	2	1	1	2
1183596	3	1	3	1	3	4	1	1	1	2
1190386	4	6	6	5	7	6	7	7	3	4
1190546	2	1	1	1	2	5	1	1	1	2
1213273	2	1	1	1	2	1	1	1	1	2
1218982	4	1	1	1	2	1	1	1	1	2
1225382	6	2	3	1	2	1	1	1	1	2
1235807	5	1	1	1	2	1	2	1	1	2
1238777	1	1	1	1	2	1	1	1	1	2
1253955	8	7	4	4	5	3	5	10	1	4
1257366	3	1	1	1	2	1	1	1	1	2
1260659	3	1	4	1	2	1	1	1	1	2
1268952	10	10	7	8	7	1	10	10	3	4
1275807	4	2	4	3	2	2	2	1	1	2
1277792	4	1	1	1	2	1	1	1	1	2
1277792	5	1	1	3	2	1	1	1	1	2
1285722	4	1	1	3	2	1	1	1	1	2
1288608	3	1	1	1	2	1	2	1	1	2
1290203	3	1	1	1	2	1	2	1	1	2
1294413	1	1	1	1	2	1	1	1	1	2
1299596	2	1	1	1	2	1	1	1	1	2
1303489	3	1	1	1	2	1	2	1	1	2
1311033	1	2	2	1	2	1	1	1	1	2
1311108	1	1	1	3	2	1	1	1	1	2
1315807	5	10	10	10	10	2	10	10	10	4
1318671	3	1	1	1	2	1	2	1	1	2
1319609	3	1	1	2	3	4	1	1	1	2
1323477	1	2	1	3	2	1	2	1	1	2
1324572	5	1	1	1	2	1	2	2	1	2
1324681	4	1	1	1	2	1	2	1	1	2
1325159	3	1	1	1	2	1	3	1	1	2
1326892	3	1	1	1	2	1	2	1	1	2

1330361	5	1	1	1	2	1	2	1	1	2
1333877	5	4	5	1	8	1	3	6	1	2
1334015	7	8	8	7	3	10	7	2	3	4
1334667	1	1	1	1	2	1	1	1	1	2
1339781	1	1	1	1	2	1	2	1	1	2
1339781	4	1	1	1	2	1	3	1	1	2
13454352	1	1	3	1	2	1	2	1	1	2
1345452	1	1	3	1	2	1	2	1	1	2
1345593	3	1	1	3	2	1	2	1	1	2
1347749	1	1	1	1	2	1	1	1	1	2
1347943	5	2	2	2	2	1	1	1	2	2
1348851	3	1	1	1	2	1	3	1	1	2
1350319	5	7	4	1	6	1	7	10	3	4
1350423	5	10	10	8	5	5	7	10	1	4
1352848	3	10	7	8	5	8	7	4	1	4
1353092	3	2	1	2	2	1	3	1	1	2
1354840	2	1	1	1	2	1	3	1	1	2
1354840	5	3	2	1	3	1	1	1	1	2
1355260	1	1	1	1	2	1	2	1	1	2
1365075	4	1	4	1	2	1	1	1	1	2
1365328	1	1	2	1	2	1	2	1	1	2
1368267	5	1	1	1	2	1	1	1	1	2
1368273	1	1	1	1	2	1	1	1	1	2
1368882	2	1	1	1	2	1	1	1	1	2
1369821	10	10	10	10	5	10	10	10	7	4
1371026	5	10	10	10	4	10	5	6	3	4
1371920	5	1	1	1	2	1	3	2	1	2
466906	1	1	1	1	2	1	1	1	1	2
466906	1	1	1	1	2	1	1	1	1	2
534555	1	1	1	1	2	1	1	1	1	2
536708	1	1	1	1	2	1	1	1	1	2
566346	3	1	1	1	2	1	2	3	1	2
603148	4	1	1	1	2	1	1	1	1	2
654546	1	1	1	1	2	1	1	1	8	2
654546	1	1	1	3	2	1	1	1	1	2
695091	5	10	10	5	4	5	4	4	1	4
714039	3	1	1	1	2	1	1	1	1	2
763235	3	1	1	1	2	1	2	1	2	2
776715	3	1	1	1	3	2	1	1	1	2
841769	2	1	1	1	2	1	1	1	1	2
888820	5	10	10	3	7	3	8	10	2	4
897471	4	8	6	4	3	4	10	6	1	4
897471	4	8	8	5	4	5	10	4	1	4

[47]

Secondly, I decided to choose group 7 as testing data, which is the data that will be used to test the accuracy and sensitivity of the algorithm. I selected twenty patients with an ID different from the other; in this way I avoid the program to collapse for not knowing which of the two IDs to choose.

[47] Figure 7: Training data from Breast Cancer Algorithm

DADES TESTING GRUP 7

ID	ESPESSOR DE C	MIDA CEL·LULA	FORMA DE LA C	ADHESIÓ	MIDA EPITELIA	NUCLI	CROMATINA	NUCLÈOLS NOR	MITOSIS	CLASSE
878358	5	7	10	6	5	10	7	5	1	4
1107684	6	10	5	5	4	10	6	10	1	4
1115762	3	1	1	1	2	1	1	1	1	2
1217717	5	1	1	6	3	1	1	1	1	2
1239420	1	1	1	1	2	1	1	1	1	2
1254538	8	10	10	10	6	10	10	10	1	4
1261751	5	1	1	1	2	1	2	2	1	2
1268275	9	8	8	9	6	3	4	1	1	4
1272166	5	1	1	1	2	1	1	1	1	2
1294261	4	10	8	5	4	1	10	1	1	4
1295529	2	5	7	6	4	10	7	6	1	4
1298484	10	3	4	5	3	10	4	1	1	4
1311875	5	1	2	1	2	1	1	1	1	2
1315506	4	8	6	3	4	10	7	1	1	4
1320141	5	1	1	1	2	1	2	1	1	2
1325309	4	1	2	1	2	1	2	1	1	2
1333063	5	1	3	1	2	1	3	1	1	2
1333495	3	1	1	1	2	1	2	1	1	2
1334659	5	2	4	1	1	1	1	1	1	2
1336798	3	1	1	1	2	1	2	1	1	2
1344449	1	1	1	1	1	1	2	1	1	2
1350568	4	1	1	1	2	1	2	1	1	2
1352663	5	4	6	8	4	1	8	10	1	4
188336	5	3	2	8	5	10	8	1	2	4
352431	10	5	10	3	5	8	7	8	3	4
353098	4	1	1	2	2	1	1	1	1	2
411453	1	1	1	1	2	1	1	1	1	2
557583	5	10	10	10	10	10	10	1	1	4
636375	5	1	1	1	2	1	1	1	1	2
736150	10	4	3	10	3	10	7	1	2	4
803531	5	10	10	10	5	2	8	5	1	4
822829	8	10	10	10	6	10	10	10	10	4

[48]

Then, I calculated the distances between the testing patients taking one as the calculation reference and thus, know how far away the other patients are from him.

To calculate the distance between the reference patient, who is in blue in the picture, and the test patient, several parameters are taken into account such as spessor, shape, size, adhesion, nucleus, nucleolus, chromatin, and mitosis of the cells. So what I did was subtract the value of the same parameter from the reference patient to the test patient and square the result.

[48] Figure 8: Testing Data from Breast Cancer Algorithm

Then, having done this with all the parameters of all the test patients, I did a square root that added all the values that we got for each parameter in each test patient. The result was the distance from one to the other.

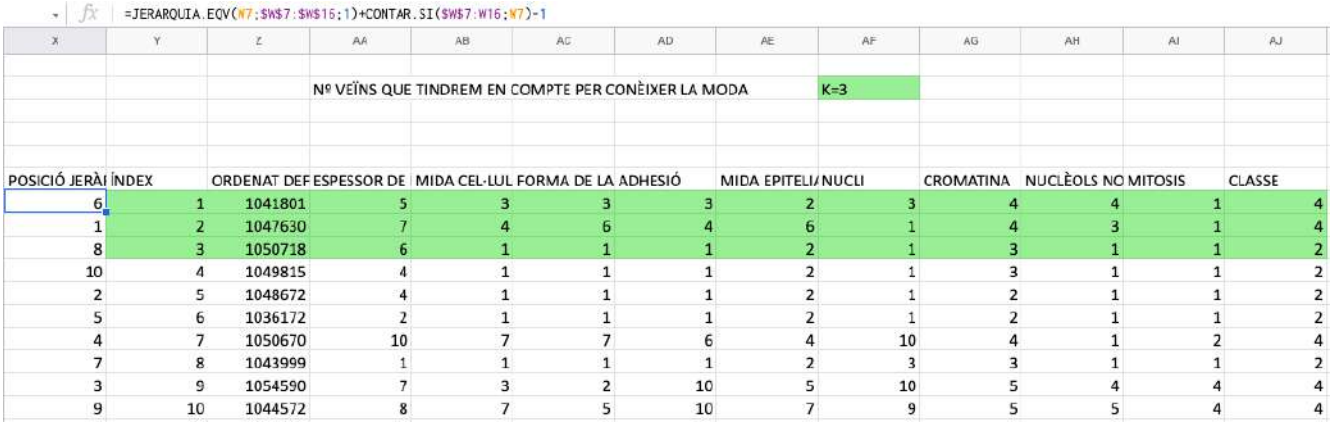
1	**Pacient Prova**										Classe Desconeguda
2	1099510	10	4	3	1	3	3	6	5	2	
3											
4											
5											
6	ID	ESPESSOR DE	MIDA CEL·LUL	FORMA DE LA	ADHESIÓ	MIDA EPITELI	NUCLI	CROMATINA	NUCLÈOLS NO	MITOSIS	CLASSE
7	1036172	2	1	1	1	2	1	2	1	1	2
8	1041801	5	3	3	3	2	3	4	4	1	4
9	1043999	1	1	1	1	2	3	3	1	1	2
10	1044572	8	7	5	10	7	9	5	5	4	4
11	1047630	7	4	6	4	6	1	4	3	1	4
12	1048672	4	1	1	1	2	1	2	1	1	2
13	1049815	4	1	1	1	2	1	3	1	1	2
14	1050670	10	7	7	6	4	10	4	1	2	4
15	1050718	6	1	1	1	2	1	3	1	1	2
16	1054590	7	3	2	10	5	10	5	4	4	4
17											
18											

ESPESSOR DE	MIDA CEL·LUL	FORMA DE LA	ADHESIÓ	MIDA EPITELI	NUCLI	CROMATINA	NUCLÈOLS	MITOSIS	CLASSE	DISTÀNCIA
64	9	4	0	1	4	16	16	1	2	10,72380529
25	1	0	4	1	0	4	1	1	4	6,082762253
81	9	4	0	1	0	9	16	1	2	11
4	9	4	81	16	36	1	0	4	4	12,4498996
9	0	9	9	9	4	4	4	1	4	7
36	9	4	0	1	4	16	16	1	2	9,327379053
36	9	4	0	1	4	9	16	1	2	8,94427191
0	9	16	25	1	49	4	16	0	4	10,95445115
16	9	4	0	1	4	9	16	1	2	7,745966692
9	1	1	81	4	49	1	1	4	4	12,28820573

[49]

The next step was to relate through the excel formulas as hierarchy and count.if the position according to the distance. Later, what I did was to relate the index formula and match formula with what I had calculated before. Here you have some pictures with the exact formulas I used.

[49] Figure 9: Calculated distances between patients from Breast Cancer Algorithm



[50]=JERARQUIA.EQV(W7;$W$7:$W$16;1)+CONTAR.SI($W$7:W16;W7)-1

[51]

=INDICE(A$7:A$16;COINCIDIR($Y7;$X$7:$X$16;0))

The final step was easier but I had to repeat it, officially, twenty times. One time for each patient.

The first thing I did in this last step was to delete all test patients from the excel table. However, the formulas were still stored in it. So now what I was interested in was to insert all the data training and consequently, the distances of them with the test patient were recalculated.

Depending on these distances, the class of the tumor was 2, which means bening, or 4, which indicates that it is malign. To know the type of the test patient's tumor, I needed to establish which type of K I would use. K is the

[50] Figure 10: Formula Jerarquia from Breast Cancer Algorithm
[51] Figure 11: Formula "Indice" from Breast Cancer Algorithm

number of neighbors I considered. If K= 3, I would take the first three patients which were the nearest ones to the test patient.

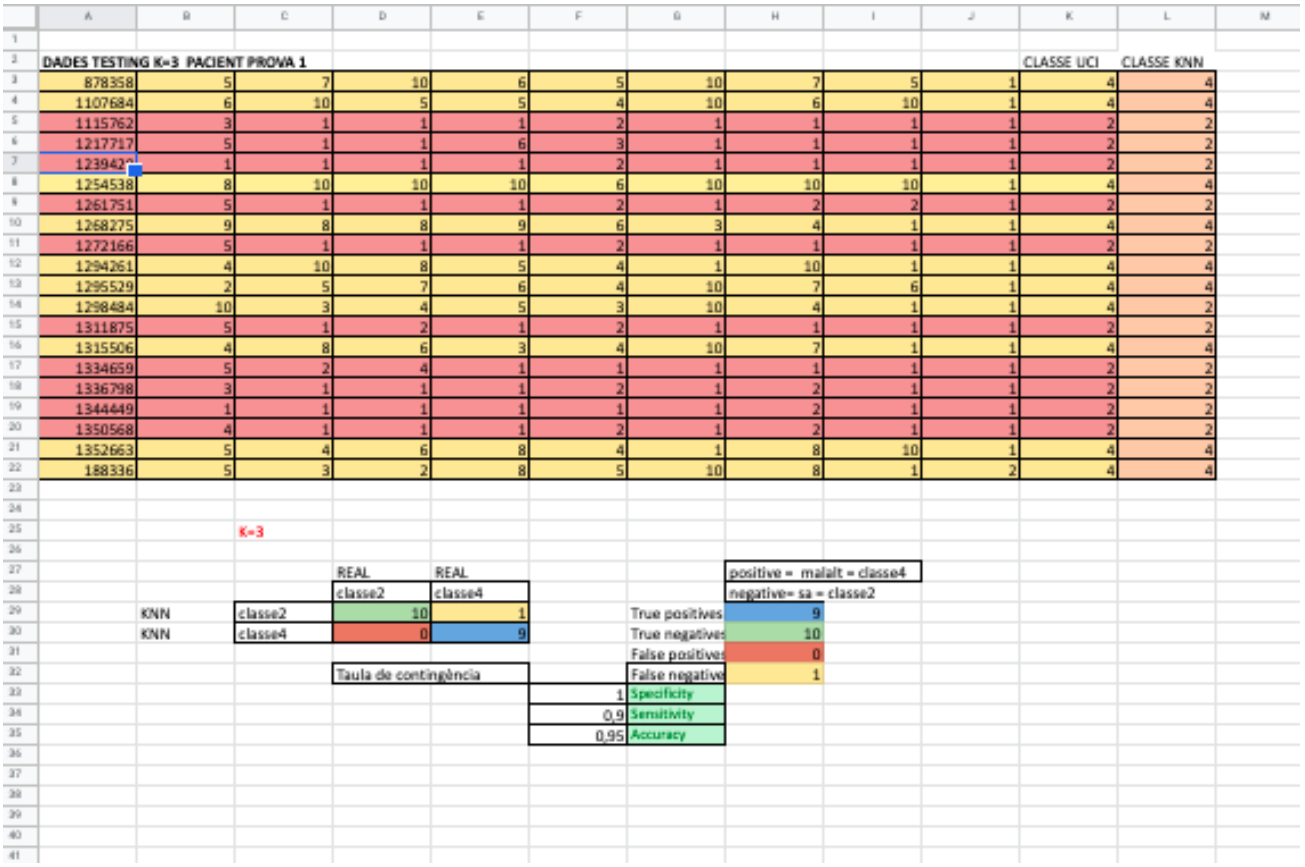
So, once I had the first three neighbors, I needed to calculate the mode between them. If it was 4, the test patient also would have a class 4 tumor; if it was 2, his class would be 2 as well.

Finally, I did all of these steps for twenty patients and I have collected all the results in an Excel sheet to synthesize the whole process. Here you have a picture of it. In addition to collecting the patient's tumor class, I calculated the specificity, which is the probability of a negative test given that the patient is well; sensitivity, which is the probability of a positive test given that the patient has the disease, and accuracy which is the degree to which the result of a measurement conforms to the correct value of the same. To calculate them I used the following formulas based on true positives (TP), true negatives (TN), false positives (FP), and false negatives (FN).

Specificity = TN / (TN + FP)

Sensitivity = TP / (TP + FN)

Accuracy = (TP + TN) / (TP + TN + FP + FN)



DADES TESTING K=3 PACIENT PROVA 1											CLASSE UCI	CLASSE KNN
878358	5	7	10	6	5	10	7	5	1		4	4
1107684	6	10	5	5	4	10	6	10	1		4	4
1115762	3	1	1	1	2	1	1	1	1		2	2
1217717	5	1	1	6	3	1	1	1	1		2	2
123942	1	1	1	1	2	1	1	1	1		2	2
1254538	8	10	10	10	6	10	10	10	1		4	4
1261751	5	1	1	1	2	1	2	2	1		2	2
1268275	9	8	8	9	6	3	4	1	1		4	4
1272166	5	1	1	1	2	1	1	1	1		2	2
1294261	4	10	8	5	4	1	10	1	1		4	4
1295529	2	5	7	6	4	10	7	6	1		4	4
1298484	10	3	4	5	3	10	4	1	1		4	2
1311875	5	1	2	1	2	1	1	1	1		2	2
1315506	4	8	6	3	4	10	7	1	1		4	4
1334659	5	2	4	1	1	1	1	1	1		2	2
1336798	3	1	1	1	2	1	2	1	1		2	2
1344449	1	1	1	1	1	1	2	1	1		2	2
1350568	4	1	1	1	2	1	2	1	1		2	2
1352663	5	4	6	8	4	1	8	10	1		4	4
188336	5	3	2	8	5	10	8	1	2		4	4

K=3

		REAL classe2	REAL classe4
KNN	classe2	10	1
KNN	classe4	0	9

Taula de contingència

positive = malalt = classe4	
negative= sa = classe2	
True positives	9
True negatives	10
False positives	0
False negative	1
1	Specificity
0,9	Sensitivity
0,95	Accuracy

52

[52] Figure 12: Data of K=3 from Breast Cancer Algorithm

53

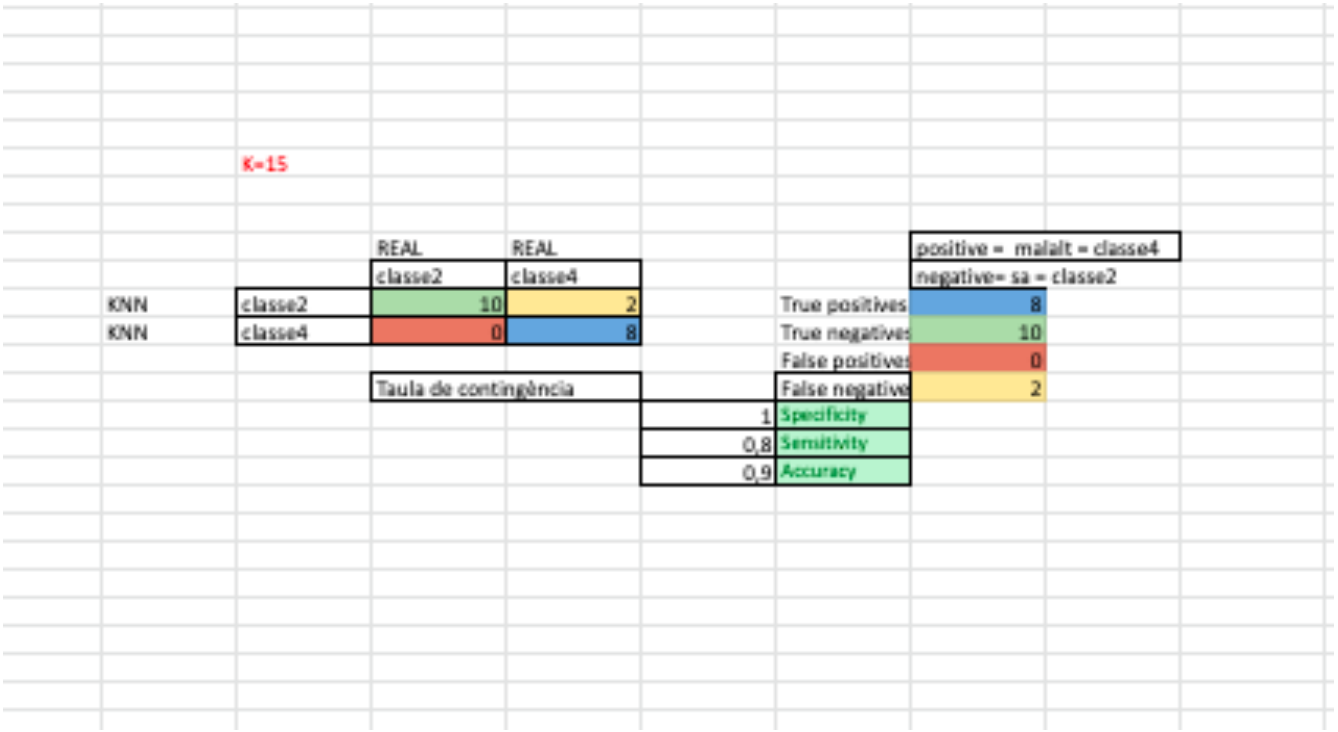
DADES TESTING K=7											CLASSE UCI	CLASSE KNN
878358	5	7	10	6	5	10	7	5	1		4	4
1107684	6	10	5	5	4	10	6	10	1		4	4
1115762	3	1	1	1	2	1	1	1	1		2	2
1217717	5	1	1	6	3	1	1	1	1		2	2
1239420	1	1	1	1	2	1	1	1	1		2	2
1254538	8	10	10	10	6	10	10	10	1		4	4
1261751	5	1	1	1	2	1	2	2	1		2	2
1268275	9	8	8	9	6	3	4	1	1		4	4
1272166	5	1	1	1	2	1	1	1	1		2	2
1294261	4	10	8	5	4	1	10	1	1		4	4
1295529	2	5	7	6	4	10	7	6	1		4	4
1298484	10	3	4	5	3	10	4	1	1		4	2
1311875	5	1	2	1	2	1	1	1	1		2	2
1315506	4	8	6	3	4	10	7	1	1		4	4
1334659	5	2	4	1	1	1	1	1	1		2	2
1336798	3	1	1	1	2	1	2	1	1		2	2
1344449	1	1	1	1	1	1	2	1	1		2	2
1350568	4	1	1	1	2	1	2	1	1		2	2
1352663	5	4	6	8	4	1	8	10	1		4	4
188336	5	3	2	8	5	10	8	1	2		4	4

K=7

		REAL classe2	REAL classe4			positive = malalt = classe4 negative= sa = classe2
KNN	classe2	10	1		True positives	9
KNN	classe4	0	9		True negatives	10
					False positives	0
		Taula de contingència			False negative	1
				1	Specificity	
				0,9	Sensitivity	
				0,95	Accuracy	

DADES TESTING K=15											CLASSE UCI	CLASSE KNN
878358	5	7	10	6	5	10	7	5	1		4	4
1107684	6	10	5	5	4	10	6	10	1		4	4
1115762	3	1	1	1	2	1	1	1	1		2	2
1217717	5	1	1	6	3	1	1	1	1		2	2
1239420	1	1	1	1	2	1	1	1	1		2	2
1254538	8	10	10	10	6	10	10	10	1		4	4
1261751	5	1	1	1	2	1	2	2	1		2	2
1268275	9	8	8	9	6	3	4	1	1		4	4
1272166	5	1	1	1	2	1	1	1	1		2	2
1294261	4	10	8	5	4	1	10	1	1		4	4
1295529	2	5	7	6	4	10	7	6	1		4	4
1298484	10	3	4	5	3	10	4	1	1		4	2
1311875	5	1	2	1	2	1	1	1	1		2	2
1315506	4	8	6	3	4	10	7	1	1		4	4
1334659	5	2	4	1	1	1	1	1	1		2	2
1336798	3	1	1	1	2	1	2	1	1		2	2
1344449	1	1	1	1	1	1	2	1	1		2	2
1350568	4	1	1	1	2	1	2	1	1		2	2
1352663	5	4	6	8	4	1	8	10	1		4	4
188336	5	3	2	8	5	10	8	1	2		4	2

[53] Figure 13: Data of K=7 from Breast Cancer Algorithm



[54]

7.7 CHALLENGES I FACED IN THE DEVELOPMENT OF THE ALGORITHM

As I have already said in my project, not everything in the garden is flowers, and that is precisely what happened to me during this project.

When I had the distances calculated, and I wanted to match them with the IDs, I found that the program collapsed since it could not choose between the same ID.

First, I didn't understand why some IDs were the same, meaning that it was the same patient. But then, I realized that it meant that the same patient was visited several times a year and fortunately, or unfortunately, obtained different results.

Notwithstanding, the program could not choose between them, so I needed to change the ID adding one; in this way, they would be different.

[54] Figure 14: Data of K=15 from Breast Cancer Algorithm

For instance, two patients with an ID of 12345678, one of them, now, would be 12345679.

But, that is the first challenge I faced, there is one left. The second one was related to the distances; When I had all the IDs different from each other, there were distances with 7 decimal places that were tied! At that moment, I couldn't believe it!

So, I contacted Dr. "x", Ph.D.to let her know about this new challenge, and we decided that we need to break the distance tie.

So, we break it through the number of patient IDs; thus, by adding the patient ID to the distance calculated before and dividing by 1,500,000; the tied distance of the repeats would no longer be three, for example, and the repeats would move to 2 or 4; in this way, there are no repeats between the distance of the IDs.

(Distance + ID)/ 1,500,000= New non-repeated distance

To sum up, this is how I faced the challenges in my algorithm. It is worth mentioning that Dr. "x", Ph.D. has helped me in all these challenges and I am so grateful to her since I have learned a lot during the process.

7.8 THE KNN IMMUNOTHERAPY ALGORITHM TO WART TREATMENT PROCEDURE THROUGH EXCEL

On the 1st of September 2021, I was invited by Dr. "x", Ph.D.to her office to develop another algorithm and also to take a tour of the ETSE building, whose acronym means Escola Tècnica Superior d'Enginyers.

In this section, I will explain the process I followed to perform this algorithm. However, in the annexes I will show in more detail, with pictures and a video, how my experience visiting the ETSE building was for the first time.

Regardless, the immunotherapy algorithm for treating warts was based on the KNN algorithm, just as I did with the breast cancer algorithm. In other words, I

followed the criteria that a KNN algorithm uses to classify the data it receives from patients that have warts and were treated with immunotherapy. The function that this algorithm performs is to predict whether the patient will respond correctly to the treatment or not.

So, as I have said previously to you, on the excel tables the formulas remain even if you delete the data. What I did was to make a copy of the excel that contains the breast cancer algorithm and delete all its data while keeping only each of the formulas on which the KNN is based.

This was the first step. For that, during its process, I had no challenges as in the breast cancer algorithm Dr. “x”, Ph.D. and I contemplated and solved all the challenges and obstacles that were put in front of us. In this case, by maintaining the formulas used we expected less or no difficulties in following the proper procedure. And so it was!

After that, I put the dataset from the UCI Repository into the document and I noticed that the attributes, which are sex, age, time, number of warts, type, area and diameter, did not have the same scale. For that, to put all the variables on the same scale and thus be able to calculate the distances, I decided to normalize the values.

Firstly, to normalize I needed to find the minimum and maximum of each column. To do this, I used excel mathematical formulas that directly give this information. These were the MIN and MAX functions.

Secondly, throughout the following formula we could extract the normalized values, which were between 0 to 1, and that would be the values from which we could calculate the distance of the patients since they were on the same scale.

y= (x-MIN)/ (MAX-MIN)

Thus, the y is the normalized value that will be in the new table from which the distances can be calculated as I have said. In the same way, the x is the non-normalized value from the older table. Once I have calculated the y, I can

drag the cells because it is calculated automatically and this way the process is even faster.

	Sex	Age	Time	Number of War	Type	Area	Induration Diam	Result of Treat
MÍNIMS	1,00	15,00	1,00	1,00	1,00	6,00	2	0
MÀXIMS	2,00	56,00	12,00	19,00	3,00	900,00	70	1

CALCULO LA TAULA DE VALORS NORMALITZATS

Sex	Age	Time	Number of War	Type	Area	Induration Diam	Result of Treatment
0	0,17	0,11	0,72	1,00	0,05	0,71	1
0	0	0,1818181818	0,05555555556	1	1	1	1
0	0,02	0,86	0,06	0,00	0,11	0,34	1
0	0,29	0,32	0,44	1,00	0,08	0,41	1
0	0,12	0,64	0,28	0,00	0,04	0,09	1
0	0,00	0,36	0,11	1,00	0,09	0,07	1
0	0,49	0,89	0,06	0,50	0,00	0,06	1
1	0,32	0,59	0,17	0,00	0,00	0,00	1
1	0,10	0,45	0,06	0,00	0,24	0,09	1
1	0,41	1,00	0,28	1,00	0,03	0,04	0
1	0,44	0,48	0,06	0,00	0,03	0,01	1
1	0,05	0,43	0,61	1,00	0,02	0,07	1
1	0,00	0,07	0,00	0,50	0,05	0,07	0
1	0,00	0,41	0,61	0,00	0,05	0,07	1
1	0,02	0,82	0,33	0,00	0,15	0,06	1
1	0,44	0,75	0,06	0,50	0,16	0,09	1
1	0,27	0,61	0,28	0,50	0,00	0,04	1
1	0,20	0,59	0,50	0,50	0,04	0,01	1
1	0,00	0,50	1,00	0,00	0,06	0,07	1
1	0,27	0,52	0,06	0,00	0,00	0,06	1
0	0,17	0,02	0,11	1,00	0,05	0,01	1
1	0,10	0,11	0,06	0,00	0,06	0,07	1
1	0,27	0,86	0,28	0,00	0,05	0,10	0
0	0,24	0,43	0,06	0,00	0,33	0,07	1
1	0,05	0,93	0,17	1,00	0,07	0,07	1
0	0,29	0,36	0,06	0,00	0,02	0,04	1
1	0,22	0,34	0,50	1,00	0,03	0,63	1
0	0,00	0,91	0,28	0,00	0,03	0,34	0
1	0,46	0,95	0,61	0,00	0,02	0,71	0
1	0,12	0,61	0,94	1,00	0,04	0,00	1
1	0,56	0,14	0,00	1,00	0,04	0,71	1
0	0,20	0,18	0,06	1,00	0,09	1,00	1
1	0,80	0,84	0,33	0,00	0,05	0,34	1
1	0,22	0,30	0,00	0,00	0,19	0,41	1
1	0,44	0,64	0,11	0,00	0,55	0,09	1
0	0,46	0,36	0,33	1,00	0,06	0,07	0
1	0,63	0,91	0,56	0,50	0,02	0,06	0
0	0,34	0,70	0,11	0,00	0,56	0,00	1
1	0,17	0,68	0,22	0,00	0,10	0,09	1
0	0,73	0,93	0,17	0,00	0,07	0,04	0
1	0,17	0,66	0,44	0,00	0,39	0,01	1

0	0,73	0,93	0,17	0,00	0,07	0,04	0	
1	0,17	0,66	0,44	0,00	0,39	0,01	1	
0	0,49	0,70	0,50	0,50	0,07	0,07	1	
1	0,46	0,68	0,00	0,50	0,18	0,07	0	
0	0,83	0,32	0,06	0,00	0,03	0,07	0	
1	0,10	0,91	0,22	0,50	0,05	0,06	1	
0	0,15	0,64	0,11	0,00	0,01	0,09	1	
0	0,27	0,61	0,67	0,50	0,01	0,04	1	
0	0,88	0,70	0,06	0,50	0,06	0,01	1	
0	0,10	0,61	0,28	0,00	0,03	0,07	1	
0	0,56	1,00	0,72	0,00	0,09	0,06	0	
1	0,51	0,07	0,50	1,00	0,04	0,01	1	
1	0,90	0,11	0,22	0,00	0,06	0,07	1	
1	0,83	0,73	0,17	0,50	0,01	0,10	1	
0	0,20	0,43	0,06	0,00	0,04	0,07	1	
0	0,73	0,82	0,39	0,00	0,06	0,07	1	
0	0,95	0,59	0,67	1,00	0,04	0,04	1	
1	0,78	0,39	0,11	1,00	0,02	0,63	1	
1	0,93	0,82	0,00	0,50	0,03	0,34	1	
1	1,00	0,98	0,33	0,00	0,03	0,71	0	
0	0,29	0,93	0,11	0,50	0,03	0,00	1	
1	0,78	0,25	0,72	0,50	0,07	0,71	1	
1	0,10	0,11	0,39	0,50	0,04	1,00	1	
1	0,44	0,64	0,22	0,00	0,06	0,34	1	
1	0,00	0,27	0,61	0,00	0,07	0,41	1	
0	0,05	0,68	0,06	0,00	0,04	0,09	1	
0	0,34	0,36	0,61	1,00	0,08	0,07	1	
0	0,29	0,98	0,39	0,00	0,23	0,06	0	
1	0,88	0,45	0,28	0,00	0,08	0,00	1	
0	0,49	0,52	0,17	1,00	0,04	0,09	1	
1	0,78	0,89	0,39	0,00	0,06	0,04	0	
0	0,68	0,64	0,00	0,00	0,06	0,01	1	
0	0,00	0,27	0,17	1,00	0,02	0,07	1	
0	0,44	0,07	0,33	0,50	0,42	0,07	0	
1	0,88	0,27	0,00	0,00	0,07	0,07	1	
0	0,73	0,50	0,44	0,50	0,05	0,06	1	
1	0,78	0,75	0,67	0,50	0,40	0,09	1	
0	0,07	0,98	0,22	0,50	0,01	0,04	1	
1	0,76	0,61	0,39	0,00	0,04	0,01	1	
0	0,68	0,91	0,33	0,00	0,56	0,07	1	
1	0,32	0,91	0,11	1,00	0,10	0,06	0	
0	0,37	0,00	0,06	0,00	0,09	0,01	1	
1	0,02	0,09	0,56	0,00	0,05	0,07	1	
1	0,66	0,70	0,39	0,50	0,07	0,10	0	
1	0,00	0,64	0,00	0,00	0,05	0,07	1	
1	0,93	0,57	0,28	0,00	0,08	0,07	1	
0	0,61	0,41	0,39	1,00	0,07	0,04	1	
0	0,56	0,59	0,39	0,50	0,06	0,63	1	
0	0,76	0,95	0,17	0,00	0,10	0,34	0	
0	0,41	1,00	0,44	0,00	0,04	0,71	0	
1	0,20	0,52	0,28	0,00	0,01	0,00	1	
						Nº 0	Nº 1	
						19	71	[55]

When I had the table above completed I needed to separate the data set into a training set and testing set, most of the data is used for training and the testing data is used to test the model by making predictions against the testing data. In this way, cells colored in pink will be part of the testing data. For that, I have grouped them in a different excel sheet.

[55] Figure 15: Table of Normalized Values from Immunotherapy Algorithm to Wart Treatment

DADES TESTING

Sex	Age	Time	Number_of_Wa	Type	Area	Induration_Dian	Result_of_Treatment
0	0,29	0,32	0,44	1,00	0,08	0,41	1
0	0,12	0,64	0,28	0,00	0,04	0,09	1
0	0,00	0,36	0,11	1,00	0,09	0,07	1
0	0,49	0,80	0,06	0,50	0,00	0,06	1
1	0,32	0,59	0,17	0,00	0,00	0,00	1
0	0,00	0,91	0,28	0,00	0,03	0,34	0
1	0,46	0,95	0,61	0,00	0,02	0,71	0
0	0,46	0,36	0,33	1,00	0,06	0,07	0
1	0,63	0,91	0,56	0,50	0,02	0,06	0
0	0,73	0,93	0,17	0,00	0,07	0,04	0

[56]

The rest of the data is the training data; here you have a picture of it.

[56] Figure 16: Testing Data from Immunotherapy Algorithm to Wart Treatment

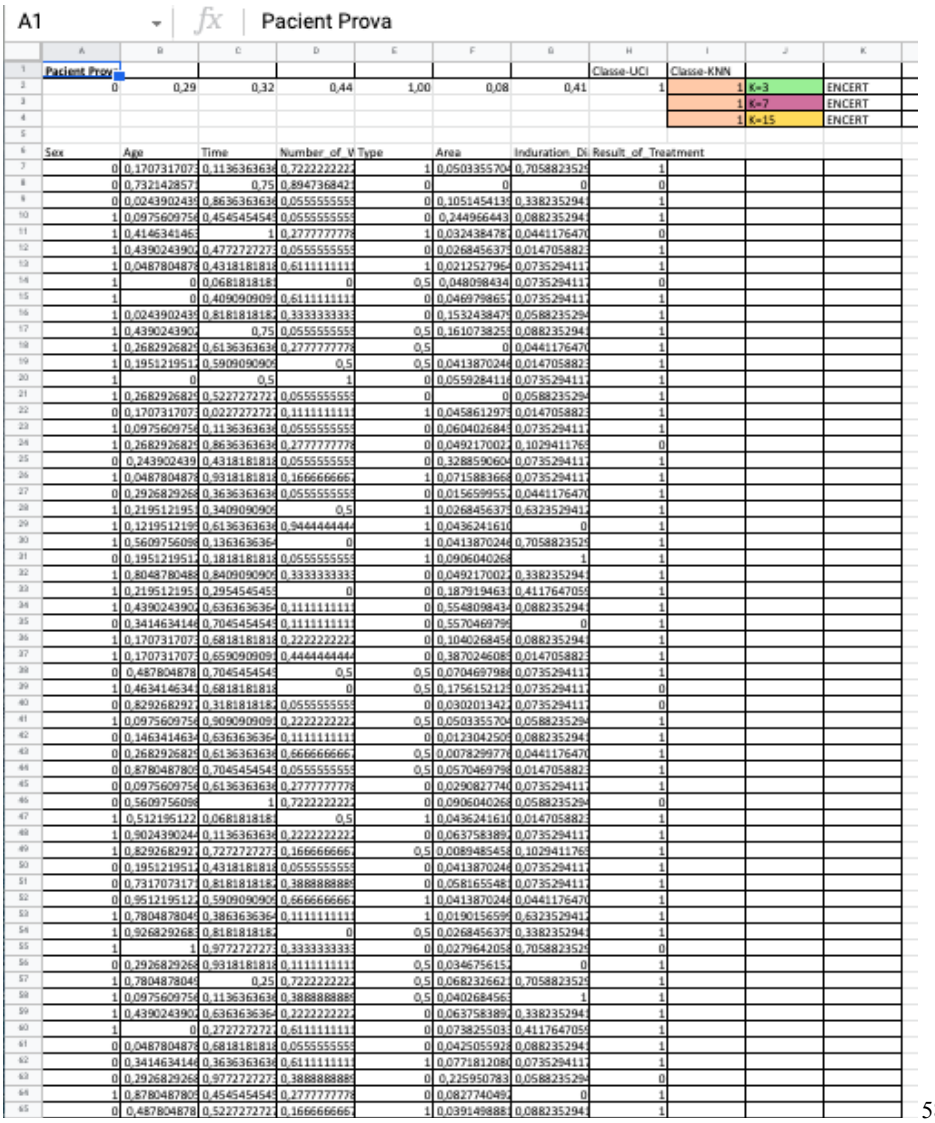
	A	B	C	D	E	F	G	H
1	Sex	Age	Time	Number_of_Wa	Type	Area	Induration_Diar	Result_of_Treatment
2	0	0,17	0,11	0,72	1,00	0,05	0,71	1
3	0	0,00	0,18	0,06	1,00	1,00	1,00	1
4	0	0,02	0,86	0,06	0,00	0,11	0,34	1
5	1	0,10	0,45	0,06	0,00	0,24	0,09	1
6	1	0,41	1,00	0,28	1,00	0,03	0,04	0
7	1	0,44	0,48	0,06	0,00	0,03	0,01	1
8	1	0,05	0,43	0,61	1,00	0,02	0,07	1
9	1	0,00	0,07	0,00	0,50	0,05	0,07	0
10	1	0,00	0,41	0,61	0,00	0,05	0,07	1
11	1	0,02	0,82	0,33	0,00	0,15	0,06	1
12	1	0,44	0,75	0,06	0,50	0,16	0,09	1
13	1	0,27	0,61	0,28	0,50	0,00	0,04	1
14	1	0,20	0,59	0,50	0,50	0,04	0,01	1
15	1	0,00	0,50	1,00	0,00	0,06	0,07	1
16	1	0,27	0,52	0,06	0,00	0,00	0,06	1
17	0	0,17	0,02	0,11	1,00	0,05	0,01	1
18	1	0,10	0,11	0,06	0,00	0,06	0,07	1
19	1	0,27	0,86	0,28	0,00	0,05	0,10	0
20	0	0,24	0,43	0,06	0,00	0,33	0,07	1
21	1	0,05	0,93	0,17	1,00	0,07	0,07	1
22	0	0,29	0,36	0,06	0,00	0,02	0,04	1
23	1	0,22	0,34	0,50	1,00	0,03	0,63	1
24	1	0,12	0,61	0,94	1,00	0,04	0,00	1
25	1	0,56	0,14	0,00	1,00	0,04	0,71	1
26	0	0,20	0,18	0,06	1,00	0,09	1,00	1
27	1	0,80	0,84	0,33	0,00	0,05	0,34	1
28	1	0,22	0,30	0,00	0,00	0,19	0,41	1
29	1	0,44	0,64	0,11	0,00	0,55	0,09	1
30	0	0,34	0,70	0,11	0,00	0,56	0,00	1
31	1	0,17	0,68	0,22	0,00	0,10	0,09	1
32	1	0,17	0,66	0,44	0,00	0,39	0,01	1
33	0	0,49	0,70	0,50	0,50	0,07	0,07	1
34	1	0,46	0,68	0,00	0,50	0,18	0,07	0
35	0	0,83	0,32	0,06	0,00	0,03	0,07	0
36	1	0,10	0,91	0,22	0,50	0,05	0,06	1
37	0	0,15	0,64	0,11	0,00	0,01	0,09	1
38	0	0,27	0,61	0,67	0,50	0,01	0,04	1
39	0	0,88	0,70	0,06	0,50	0,06	0,01	1
40	0	0,10	0,61	0,28	0,00	0,03	0,07	1
41	0	0,56	1,00	0,72	0,00	0,09	0,06	0
42	1	0,51	0,07	0,50	1,00	0,04	0,01	1
43	1	0,90	0,11	0,22	0,00	0,06	0,07	1
44	1	0,83	0,73	0,17	0,50	0,01	0,10	1
45	0	0,20	0,43	0,06	0,00	0,04	0,07	1
46	0	0,73	0,82	0,39	0,00	0,06	0,07	1
47	0	0,95	0,59	0,67	1,00	0,04	0,04	1
48	1	0,78	0,39	0,11	1,00	0,02	0,63	1
49	1	0,93	0,82	0,00	0,50	0,03	0,34	1
50	1	1,00	0,98	0,33	0,00	0,03	0,71	0
51	0	0,29	0,93	0,11	0,50	0,03	0,00	1
52	1	0,78	0,25	0,72	0,50	0,07	0,71	1
53	1	0,10	0,11	0,39	0,50	0,04	1,00	1
54	1	0,44	0,64	0,22	0,00	0,06	0,34	1
55	1	0,00	0,27	0,61	0,00	0,07	0,41	1
56	0	0,05	0,68	0,06	0,00	0,04	0,09	1
57	0	0,34	0,36	0,61	1,00	0,08	0,07	1
58	0	0,29	0,98	0,39	0,00	0,23	0,06	0
59	1	0,88	0,45	0,28	0,00	0,08	0,00	1
60	0	0,49	0,52	0,17	1,00	0,04	0,09	1

A	B	C	D	E	F	G	H
1	0,78	0,75	0,67	0,50	0,40	0,09	1
0	0,07	0,98	0,22	0,50	0,01	0,04	1
1	0,76	0,61	0,39	0,00	0,04	0,01	1
0	0,68	0,91	0,33	0,00	0,56	0,07	1
1	0,32	0,91	0,11	1,00	0,10	0,06	0
0	0,37	0,00	0,06	0,00	0,09	0,01	1
1	0,02	0,09	0,56	0,00	0,05	0,07	1
1	0,66	0,70	0,39	0,50	0,07	0,10	0
1	0,00	0,64	0,00	0,00	0,05	0,07	1
1	0,93	0,57	0,28	0,00	0,08	0,07	1
0	0,61	0,41	0,39	1,00	0,07	0,04	1
0	0,56	0,59	0,39	0,50	0,06	0,63	1
0	0,76	0,95	0,17	0,00	0,10	0,34	0
0	0,41	1,00	0,44	0,00	0,04	0,71	0
1	0,20	0,52	0,28	0,00	0,01	0,00	1

[57]

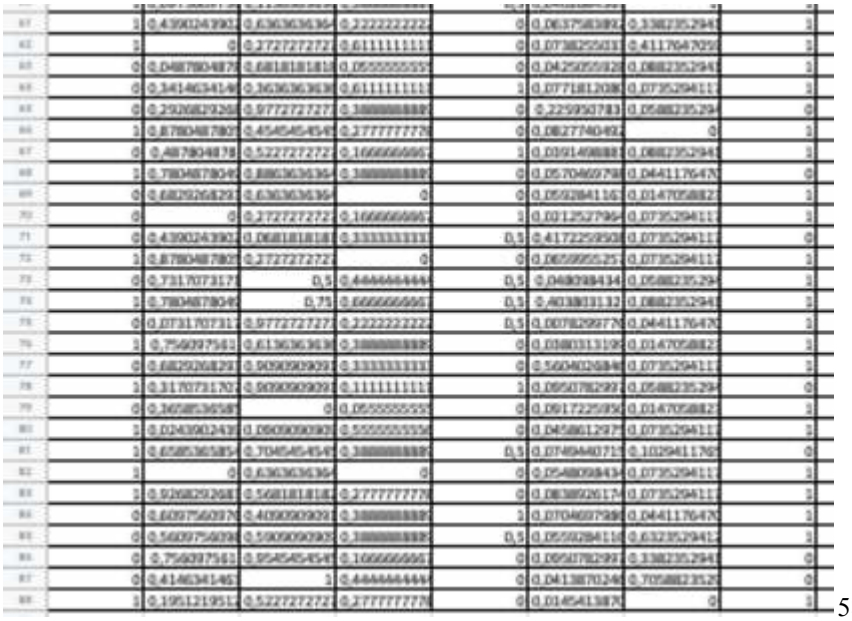
[57] Figure 17: Training Data from Immunotherapy Algorithm to Wart Treatment

Next, I pasted all the training data into the excel document that had all the formulas saved; in this way, the distances were automatically calculated and through the mode I could know if the results of the treatment to each patient were successful or not as well as whether the algorithm had matched the real result.



A1 | Pacient Prova

	A	B	C	D	E	F	G	H	I	J	K
1	Pacient Prov							Classe-UCI	Classe-KNN		
2	0	0,29	0,32	0,44	1,00	0,08	0,41	1	1	K=3	ENCERT
3									1	K=7	ENCERT
4									1	K=15	ENCERT
5											
6	Sex	Age	Time	Number_of_V	Type	Area	Induration_Di	Result_of_Treatment			
7	0	0,1707317073	0,1136363636	0,7222222222	1	0,0503355704	0,7058823529	1			
8	0	0,7321428571	0,75	0,8947368421	0	0	0	0			
9	0	0,0243902439	0,8636363636	0,0555555555	0	0,1051454138	0,3382352941	1			
10	1	0,0975609756	0,4545454545	0,0555555555	0	0,244966443	0,0882352941	1			
11	1	0,4146341463	1	0,2777777778	1	0,0324384787	0,0441176471	0			
12	1	0,4390243902	0,4772727273	0,0555555555	0	0,0268456375	0,0147058823	1			
13	1	0,0487804878	0,4318181818	0,6111111111	1	0,0212527964	0,0735294117	1			
14	1	0	0,0681818182	0	0,5	0,048098434	0,0735294117	0			
15	1	0	0,4090909091	0,6111111111	0	0,0469798657	0,0735294117	1			
16	1	0,0243902439	0,8181818182	0,3333333333	0	0,1532438479	0,0588235294	1			
17	1	0,4390243902	0,75	0,0555555555	0,5	0,1610738255	0,0882352941	1			
18	1	0,2682926829	0,6136363636	0,2777777778	0,5	0	0,0441176471	1			
19	1	0,1951219512	0,5909090909	0,5	0,5	0,0413870246	0,0147058823	1			
20	1	0	0,5	1	0	0,0559284116	0,0735294117	1			
21	1	0,2682926829	0,5227272727	0,0555555555	0	0	0,0588235294	1			
22	0	0,1707317073	0,0227272727	0,1111111111	1	0,0458612975	0,0147058823	1			
23	1	0,0975609756	0,1136363636	0,0555555555	0	0,0604026846	0,0735294117	1			
24	1	0,2682926829	0,8636363636	0,2777777778	0	0,0492170022	0,1029411765	0			
25	0	0,243902439	0,4318181818	0,0555555555	0	0,3288590604	0,0735294117	1			
26	1	0,0487804878	0,9318181818	0,1666666667	1	0,0715883668	0,0735294117	1			
27	0	0,2926829268	0,3636363636	0,0555555555	0	0,0156599553	0,0441176471	1			
28	1	0,2195121951	0,3409090909	0,5	1	0,0268456375	0,6323529412	1			
29	1	0,1219512195	0,6136363636	0,9444444444	1	0,0436241611	0	1			
30	1	0,5609756098	0,1363636364	0	1	0,0413870246	0,7058823529	1			
31	0	0,1951219512	0,1818181818	0,0555555555	1	0,0906040268	1	1			
32	1	0,8048780488	0,8409090909	0,3333333333	0	0,0492170022	0,3382352941	1			
33	1	0,2195121951	0,2954545455	0	0	0,187919463	0,4117647059	1			
34	1	0,4390243902	0,6363636364	0,1111111111	0	0,5548098434	0,0882352941	1			
35	0	0,3414634146	0,7045454545	0,1111111111	0	0,5570469799	0	1			
36	1	0,1707317073	0,6818181818	0,2222222222	0	0,1040268456	0,0882352941	1			
37	1	0,1707317073	0,6590909091	0,4444444444	0	0,3870246085	0,0147058823	1			
38	0	0,487804878	0,7045454545	0,5	0,5	0,0704697986	0,0735294117	1			
39	1	0,4634146341	0,6818181818	0	0,5	0,1756152125	0,0735294117	0			
40	0	0,8292682927	0,3181818182	0,0555555555	0	0,0302013423	0,0735294117	0			
41	1	0,0975609756	0,9090909091	0,2222222222	0,5	0,0503355704	0,0588235294	1			
42	0	0,1463414634	0,6363636364	0,1111111111	0	0,0123042506	0,0882352941	1			
43	0	0,2682926829	0,6136363636	0,6666666667	0,5	0,0078299776	0,0441176471	1			
44	0	0,8780487805	0,7045454545	0,0555555555	0,5	0,0570469799	0,0147058823	1			
45	0	0,0975609756	0,6136363636	0,2777777778	0	0,0290827740	0,0735294117	1			
46	0	0,5609756098	1	0,7222222222	0	0,0906040268	0,0588235294	0			
47	1	0,5121951220	0,0681818182	0,5	1	0,0436241611	0,0147058823	1			
48	1	0,9024390244	0,1136363636	0,2222222222	0	0,0637583892	0,0735294117	1			
49	1	0,8292682927	0,7272727273	0,1666666667	0,5	0,0089485458	0,1029411765	1			
50	0	0,1951219512	0,4318181818	0,0555555555	0	0,0413870246	0,0735294117	1			
51	0	0,7317073171	0,8181818182	0,3888888889	0	0,0581655481	0,0735294117	1			
52	0	0,9512195122	0,5909090909	0,6666666667	1	0,0413870246	0,0441176471	1			
53	1	0,7804878049	0,3863636364	0,1111111111	1	0,0190156599	0,6323529412	1			
54	1	0,9268292683	0,8181818182	0	0,5	0,0268456375	0,3382352941	1			
55	1	1	0,9772727273	0,3333333333	0	0,0279642058	0,7058823529	0			
56	0	0,2926829268	0,9318181818	0,1111111111	0,5	0,0346756152	0	1			
57	1	0,7804878049	0,25	0,7222222222	0,5	0,0682326621	0,7058823529	1			
58	1	0,0975609756	0,1136363636	0,3888888889	0,5	0,0402684564	1	1			
59	1	0,4390243902	0,6363636364	0,2222222222	0	0,0637583892	0,3382352941	1			
60	1	0	0,2727272727	0,6111111111	0	0,0738255034	0,4117647059	1			
61	0	0,0487804878	0,6818181818	0,0555555555	0	0,0425055928	0,0882352941	1			
62	0	0,3414634146	0,3636363636	0,6111111111	1	0,0771812080	0,0735294117	1			
63	0	0,2926829268	0,9772727273	0,3888888889	0	0,2259507830	0,0588235294	0			
64	1	0,8780487805	0,4545454545	0,2777777778	0	0,0827740492	0	1			
65	0	0,487804878	0,5227272727	0,1666666667	1	0,0391498881	0,0882352941	1			



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		Nº VEÏNS QUE TINDREM EN COMPTE PER CONÈIXER LA MODA				K=3		
		Nº VEÏNS QUE TINDREM EN COMPTE PER CONÈIXER LA MODA				K=7		
		Nº VEÏNS QUE TINDREM EN COMPTE PER CONÈIXER LA MODA				K=15		
ÍNDEX	Sex	Age	Time	Number_of_V	Type	Area	Induration_Di	Result_of_Treatment
1	1	0,219512195	0,340909090	0,5	1	0,026845637	0,632352941	1
2	0	0,341463414	0,363636363	0,611111111	1	0,077181208	0,073529411	1
3	1	0,048780487	0,431818181	0,611111111	1	0,021252796	0,073529411	1
4	0	0,170731707	0,113636363	0,722222222	1	0,050335570	0,705882352	1
5	0	0,609756097	0,409090909	0,388888888	1	0,070469798	0,044117647	1
6	0	0,487804878	0,522727272	0,166666666	1	0,039149888	0,088235294	1
7	1	0,512195122	0,068181818	0,5	1	0,043624161	0,014705882	1
8	0	0	0,272727272	0,166666666	1	0,021252796	0,073529411	1
9	0	0,170731707	0,022727272	0,111111111	1	0,045861297	0,014705882	1
10	1	0,560975609	0,136363636	0	1	0,041387024	0,705882352	1
11	1	0,780487804	0,386363636	0,111111111	1	0,019015659	0,632352941	1
12	0	0,560975609	0,590909090	0,388888888	0,5	0,055928411	0,632352941	1
13	1	0,195121951	0,590909090	0,5	0,5	0,041387024	0,014705882	1
14	1	0,268292682	0,613636363	0,277777777	0,5	0	0,044117647	1
15	0	0,195121951	0,181818181	0,055555555	1	0,090604026	1	1
16	0	0,268292682	0,613636363	0,666666666	0,5	0,007829977	0,044117647	1
17	1	0,121951219	0,613636363	0,944444444	1	0,043624161	0	1
18	0	0,487804878	0,704545454	0,5	0,5	0,070469798	0,073529411	1
19	0	0,731707317	0,5	0,444444444	0,5	0,048098434	0,058823529	1
20	1	0,048780487	0,931818181	0,166666666	1	0,071588366	0,073529411	1
21	1	0,780487804	0,25	0,722222222	0,5	0,068232662	0,705882352	1
22	1	0,097560975	0,113636363	0,388888888	0,5	0,040268456	1	1

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From there, the only step left was to repeat the process for the ten test patients and calculate, as I did with the other algorithm, the specificity, sensitivity and accuracy with the formulas I had shown you before. For that, I have collected all the results in an Excel sheet to synthesize the whole process. Here you have a picture of it.

[58] Figure 18: Calculated Distances with Standardized Values

DADES TESTING K=3 PACIENT PROVA 1

Sex	Age	Time	Number_of_W	Type	Area	Induration_Dia	RESULT UCI	RESULT KNN
0	0,29	0,32	0,44	1,00	0,08	0,41	1	1
0	0,12	0,64	0,28	0,00	0,04	0,09	1	1
0	0,00	0,36	0,11	1,00	0,09	0,07	1	1
0	0,49	0,80	0,06	0,50	0,00	0,06	1	1
1	0,32	0,59	0,17	0,00	0,00	0,00	1	1
0	0,00	0,91	0,28	0,00	0,03	0,34	0	1
1	0,46	0,95	0,61	0,00	0,02	0,71	0	1
0	0,46	0,36	0,33	1,00	0,06	0,07	0	1
1	0,63	0,91	0,56	0,50	0,02	0,06	0	0
0	0,73	0,93	0,17	0,00	0,07	0,04	0	1

K=3

		REAL result 1	REAL result 0
KNN	result 1	5	4
KNN	result 0	0	1

Taula de contingència

True positives	1
True negatives	5
False positives	0
False negative	4
1	Specificity
0,2	Sensitivity
0,6	Accuracy

Result 1= eficàcia en el tractament d'Immunotherapy
Result 0= no és eficaç el tractament amb Immunothrapy per tractar les berrugues

59

DADES TESTING K=7 PACIENT PROVA 1

Sex	Age	Time	Number_of_W	Type	Area	Induration_Dia	RESULT UCI	RESULT KNN
0	0,29	0,32	0,44	1,00	0,08	0,41	1	1
0	0,12	0,64	0,28	0,00	0,04	0,09	1	1
0	0,00	0,36	0,11	1,00	0,09	0,07	1	1
0	0,49	0,80	0,06	0,50	0,00	0,06	1	1
1	0,32	0,59	0,17	0,00	0,00	0,00	1	1
0	0,00	0,91	0,28	0,00	0,03	0,34	0	1
1	0,46	0,95	0,61	0,00	0,02	0,71	0	1
0	0,46	0,36	0,33	1,00	0,06	0,07	0	1
1	0,63	0,91	0,56	0,50	0,02	0,06	0	1
0	0,73	0,93	0,17	0,00	0,07	0,04	0	1

K=7

		REAL result 1	REAL result 0
KNN	result 1	5	5
KNN	result 0	0	0

Taula de contingència

True positives	0
True negatives	5
False positives	0
False negative	5
1	Specificity
0	Sensitivity
0,5	Accuracy

Result 1= eficàcia en el tractament d'Immunotherapy
Result 0= no és eficaç el tractament amb Immunothrapy per tractar les berrugues

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[59] Figure 19: Data of K=3 from Immunotherapy Algorithm to Wart Treatment
[60] Figure 20: Data of K=7 from ImmunotherapyAlgorithm to Wart Treatment

DADES TESTING K=15 PACIENT PROVA 1

Sex	Age	Time	Number_of_W	Type	Area	Induration_Dia	RESULT UCI	RESULT KNN
0	0,29	0,32	0,44	1,00	0,08	0,41	1	1
0	0,12	0,64	0,28	0,00	0,04	0,09	1	1
0	0,00	0,36	0,11	1,00	0,09	0,07	1	1
0	0,49	0,80	0,06	0,50	0,00	0,06	1	1
1	0,32	0,59	0,17	0,00	0,00	0,00	1	1
0	0,00	0,91	0,28	0,00	0,03	0,34	0	1
1	0,46	0,95	0,61	0,00	0,02	0,71	0	1
0	0,46	0,36	0,33	1,00	0,06	0,07	0	1
1	0,63	0,91	0,56	0,50	0,02	0,06	0	1
0	0,73	0,93	0,17	0,00	0,07	0,04	0	1

61

K=15

		REAL result 1	REAL result 0
KNN	result 1	5	5
KNN	result0	0	0

Taula de contingència

1	Specificity
0	Sensitivity
0,5	Accuracy

Result 1= eficàcia en el tractament d'immunotherapy
Result 0= no és eficaç el tractament amb immunothrapy per tractar les berrugues

True positives	0
True negatives	5
False positives	0
False negative	5

Globally, the specificity, sensitivity and effectiveness show that the algorithm is able to detect whether the patient will respond correctly to warts' treatment but is unable to predict when treatment of warts with immunotherapy will not be effective for the patient.

In the UCI immunotherapy dataset, there were 90 patients registered so I took the whole dataset and when I started to develop the algorithm I realized that only 15 patients in the set did not respond satisfactorily to wart immunotherapy treatment, labeled as class 0; instead there were 75 who responded perfectly to treatment, labeled as class 1. This is a case of **unbalanced data**, which means that the target variable has more observations in one specific class than the other. In this way, we could say that the dataset has not a proportional amount of information for both classes and this provokes unreliable results in the machine learning system.

[61] Figure 21: Data of K=15 from Immunotherapy Algorithm to Wart Treatment

Evenmore, as we have learned in previous chapters, **if the machine is not fed with enough information it will not learn with the maximum accuracy** to deliver reliable results and this is what happens in this case.

What I also intend to demonstrate with this algorithm is that there is a huge gap to achieve the true accuracy that artificial intelligence is capable of. This is due to the fact that to achieve this accuracy and excellence in real life we need to overcome the most difficult of all obstacles: the intrusion into our private lives.

Even though it can be a bit annoying because everything, absolutely everything would have to be recorded to obtain reliable results, this is not so negative because there would be a lot of protection with our personal data. Yet, do you think we are willing to make that compromise with ourselves and the society?

8.0 CONCLUSIONS

Once the research carried out throughout the work both biographical and experimental has been completed, I have been able to reflect on the hypothesis put forward, which I can say with total certainty is true.

It referred to the power of AI to transform people's lives and improve exponentially the current healthcare system. This is a claim that could well be corroborated by bibliographic research, but it has been through the practical framework that I have been able to quantify the extent to which the impact of AI could be great for humanity.

As I have explained previously, my practical framework consisted of creating two algorithms: one is able to predict whether the patient will respond correctly to Immunotherapy or not and the second one is an algorithm that can detect and prognosticate, in a dataset, Breast Cancer.

With these algorithms, I have applied artificial intelligence but one of the best moments creating them was when I saw an incredible accuracy with the Breast Cancer Algorithm, specifically 95% and also when, with the 2nd algorithm, I discovered that there is a long way to go with artificial intelligence, because the gap of information and the digitization of this data greatly determines the performance of the algorithm. Therefore, as the future generation that we are, we have the goal of finding a way to implement AI since it can save our lives, improve our health, and even achieve the cheapest treatments of history!

In the same way, I am sure that artificial intelligence, which only needs a large amount of data, can solve simple to complex problems, and that is surprising because in life there are no black or white situations, but they all have different nuances.

Thus, artificial intelligence shows us the versatility it has for some situations and others, and that is why it is a great hope for solving many of our society's challenges.
Artificial intelligence is a relatively new branch of technology because years ago there were not the appropriate technologies to develop complex programs such as those being carried out today.

Although I have decided to focus on its application in the field of medicine, its implementation in our lives is everywhere. It can help people in all fields apart from medicine such as in marketing, social networks, advertising, chat boxes, agriculture and farming, retail, shopping and fashion, security and surveillance, banking, sports analytics, production and manufacturing, and so on. Hey, what do you think about it? Impressive, isn't it? ;)

In the field of medicine, AI can be a great ally in people's lives since it only needs data. If humans can provide it, the system can predict, analyze, make patterns among groups, and even tell if you have a disease and which treatment you can follow to get better! Following this way, malpractice and misdiagnosis will potentially be reduced, and obviously, all of the foregoing will be done with medical supervision!

Over the years, AI will increase its patient data, which means that the patient will be closely monitored and any sudden change in the patient's organism will immediately be notified to prevent the disease and thus ensure health in our society.

In the same way, artificial intelligence can develop personalized drugs and treatments, providing them with speed and precision and knowing, through the patient monitoring, the appropriate dose for him.

However, where I think AI will have the most impact on healthcare is in turning today's medicine into one that its concerns are related not to time but to the patient, not to the treatment that will be good for the population but to the treatment that will fit the patient's needs, not with money but with the patient, not with hacking but with patient privacy, not with distraction but with care, not treating with distance, but with closeness, not with curing a disease but with healing it, and not with the cure of the illness but with the prevention of it.

Artificial intelligence is proof that science and technology can merge to achieve something higher; It is proof that we have everything we need here on Earth to

create solutions to our concerns. Our survival only depends on the direction in which we focus.

To reach these conclusions, I have gradually and carefully achieved every one of the objectives proposed at the beginning.

Thanks to the whole series of sections and subsections of the theoretical framework I have learned, known and deepened two very small but at the same time all-encompassing worlds, AI and medicine. From these, I have learned more specifically, their current functioning as well as their impact on health through innovative and sophisticated techniques such as making algorithms.

I have been able to finish understanding these techniques, along with all the knowledge acquired through bibliographic research, thanks to the practical part in which I have applied and taken into account all the knowledge I have gained throughout this project.

To conclude this work, I would like to convey a message to those who still have within themselves the concern and fear about artificial intelligence and its application, especially in the field of health, since it is on this one that our lives depend on.

That is why I would tell them that we are going down the right path and that even though this may be long and full of obstacles, more and more light is distinguished at its end.

Changes require effort as we have to adapt to them, but together we will be able to get rid of fear and take advantage of the most powerful tool that has ever existed in humanity. Artificial intelligence will improve our lives and will make them easier if we finally decide to implement it. Let's give it a chance!

9.0 ACKNOWLEDGEMENTS

When I started this work I remember that I saw the moment of finishing it very far away and at the same time diffused by a fear of starting it. But now that I

have finished it, the feeling of satisfaction is so gratifying that I can say that all the effort and time spent has been worth it!

Firstly, to be able to tell myself that I have succeeded, that I have completed this project successfully and, at the same time, that I have fulfilled all the objectives that I had set for myself from the beginning.

Secondly, because this work has given me knowledge, new perspectives and ideas, as well as experiences that I would never have imagined to be so enriching.

This research work has made me grow as a person. It has made me aware that our healthcare system needs a change and that I want to be part of it. I want to study medicine and become a great physician.

I know this is not an easy challenge for our society, far from it but I also know that changes are very difficult at the beginning and marvelous at the end!

So yes and yes, I am willing to be a great doctor and yes I am also willing to improve the current healthcare system with the goal of improving people's quality of life.

Notwithstanding, this project would not be the same without the following amazing people. I would like to thank them whether they have been part of this project directly or indirectly.

First of all and with great gratitude, thanks to my native tutor “M” for daring to take a scientific work, although it was not his specialty, as well as for accompanying me in this adventure of getting to know two small worlds, artificial intelligence together with Medicine, which I have discovered that they provide us with a wide range of benefits for the entire population.
In second place but with the greatest gratitude to Dr. “x”, Ph.D.for giving me the incredible opportunity to perform a part of the practical framework in a university environment within reach of a series of machinery and work tools that I would never have thought I would get to know. Thank you, Dr. “x”,

Ph.D.for helping me at all times, for all the hours dedicated to my doubts and questions, and for sharing with me much of your knowledge.

Thanks to my tutor “M” and Dr. “x”, Ph.D. for always responding and making a hole in their very busy schedule.

Finally, thanks to my family, who have always been there supporting me and walking by my side during the development of this project, being critical in each of the sections in which I asked them for their opinion, as well as respecting and admiring my way of communicating things, and finally I would like to thank them for their encouragement and patience in the hardest moments of the work.

Thank you from the heart to all of you!

Sincerely,

“A”

10.0 ANNEXES

10.1 MY FIRST TIME VISITING THE URV!

When Dr. “x”, Ph.D. invited me to the University Rovira I Virgili to develop another algorithm and visit the University I could not believe it! So, I accepted,

and on the first of September of 2021, I went there! It was amazing visiting the URV when there was nobody. There was silence but the student atmosphere could be felt and I was fascinated!

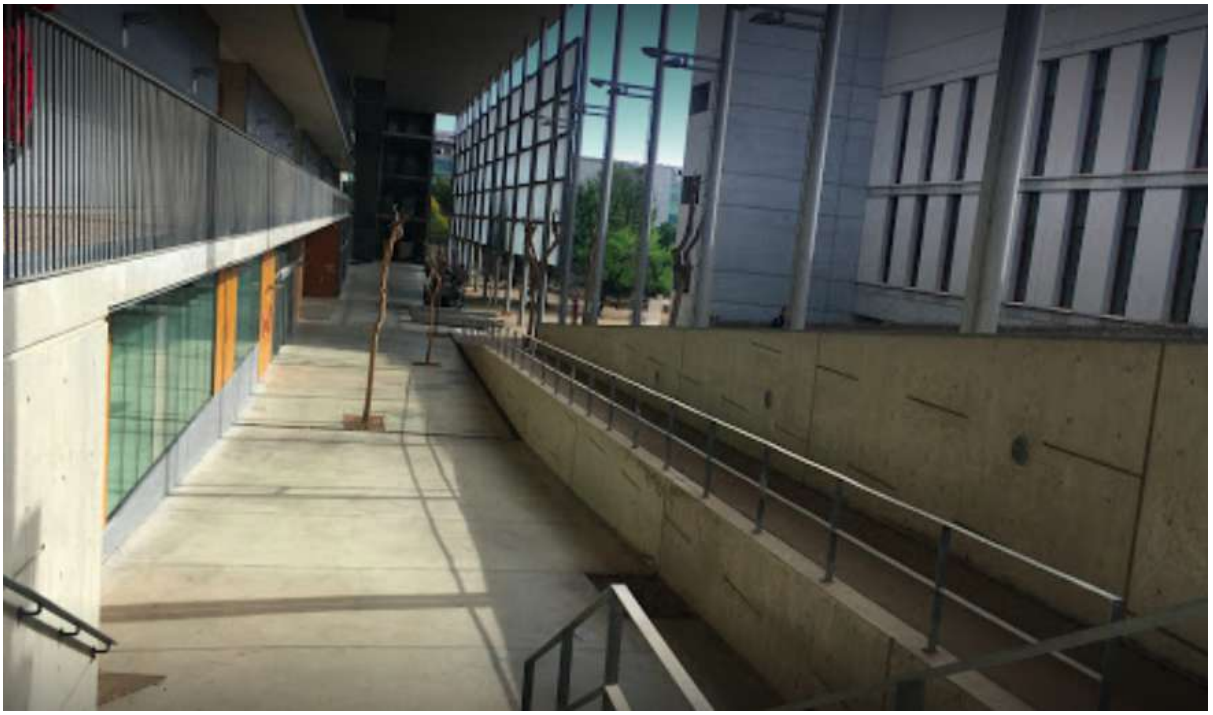
While I was developing the second algorithm in the laboratories, I knew two Ph.D. students, who were working there on different projects and were so kind to me. One of them was from Yemen and that means that the URV is such an international University!

Here you have pictures of the University during my experience at the URV.

This is the ETSE, which means Escola Tècnica Superior d'Enginyers. It belongs to the URV and here is where I stayed during the process of developing the second algorithm.

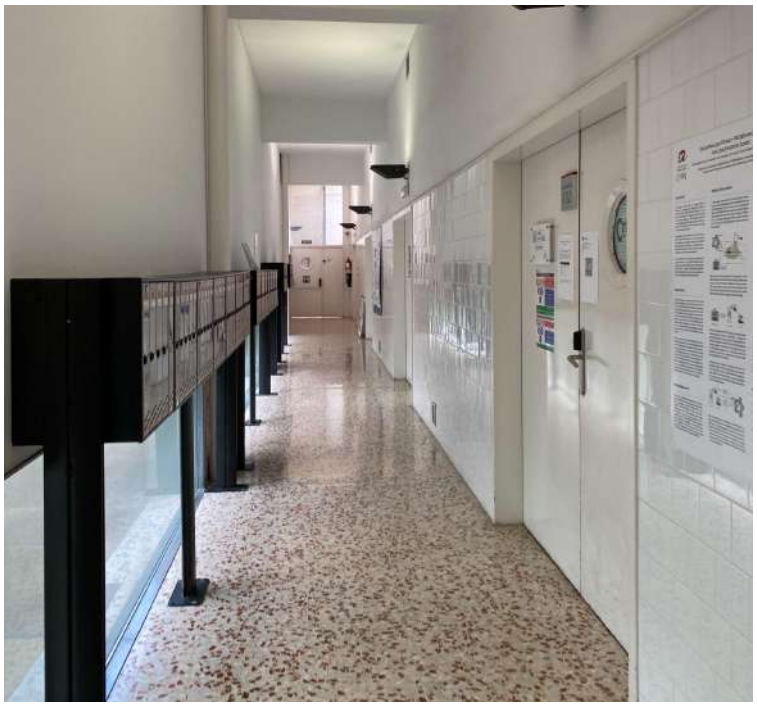
In these pictures it can be seen, the hallway of the professor's offices in which there is the office of Dr. "x", Ph.D. and even my brother and I touring it.

Here you have a picture of Dr. “x”, Ph.D. on the right, and me, on the left, on the Department of Computer Engineering and Mathematics.



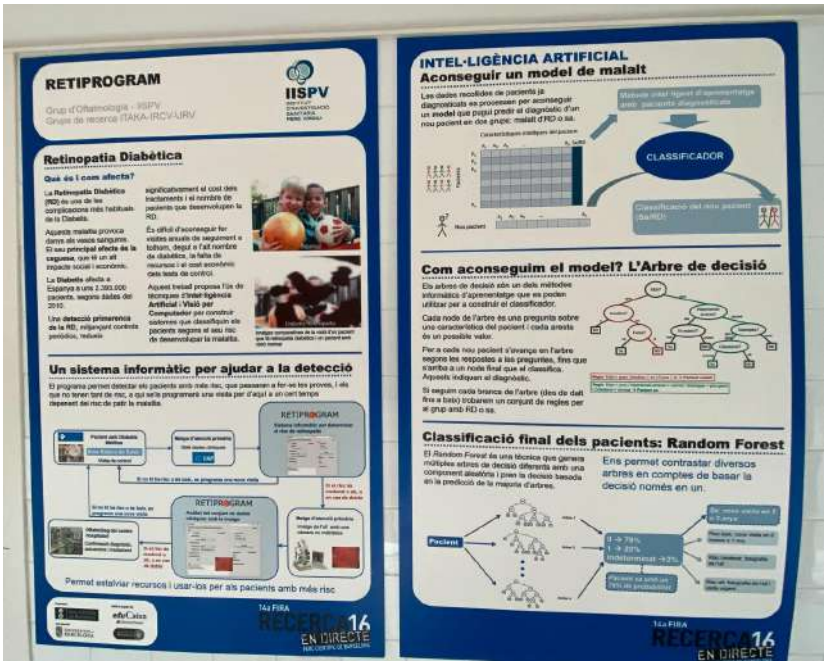
In the ETSE from URV, which means Escola Tècnica Superior d'Enginyeria, all the corridors are outdoors, in other words, in the open air, and this makes it much easier to ensure compliance with regulations during this covid-19 situation. Here you can see some of the outdoor courtyards of the university.

Before going to the laboratories, Dr. “x”, Ph.D.showed me the CRAI of the URV, which acronym means Centre de Recursos per a l’Aprenentatge i la Investigació. My teachers at school have recommended me for searching some scientific articles to the TDR to consult the CRAI and seeing it so close impacted me a little, honestly.



This is the corridor of math laboratories. In one of them, I developed the KNN Immunotherapy Algorithm to Wart Treatment. Here you have some photos from the inside.

On one of the walls, there was this poster that consists of a project in which they are working on since 2016. It is about detecting in a faster way diabetic retinopathy using artificial intelligence. I was fascinated by this project so I took a picture of it to learn more about it at home!



Finally, I would like to show you a brief moment of the visit in which I thank Dr. "x", Ph.D.for everything she has done during these months, helping me throughout the process. It is a video so here you have a QR to see it in a proper way.

10.2 MY DAILY EXPERIENCE DOING THIS RESEARCH PAPER

I will never forget the day I started this project. A project that has been part of my daily life for almost three months now. That is why I thought that having a fraction of my thoughts at that moment would be so interesting and valuable, for whoever reads it, but especially for years later, when I reread this paper immersed in the curiosity and longing of my student youth.

12-07-2021

Once I have finished the Summer School of the Dual Diploma, taking Concepts of Engineering & Technology, I am about to continue the practical part, which I left aside when I started the summer course of the Dual Diploma, before Dr. "x", Ph.D. goes on vacation in August. The idea, as I told Dr. "x", Ph.D., would be to finish the Algorithm before the vacation period starts.

Last June 11th we met and started.ñ to build this project that aims to detect breast cancer, specifically the type of tumor, benign or malignant, from data provided by the UCI repository.

This algorithm is based on the KNN algorithm model which aims to find the nearest neighbors by calculating the distance from the patient using mathematical formulas.

The objective is to establish a mode that will be the result that he will issue as a final verdict. With Dr. “x”, Ph.D. we have discussed that if it would give us times we can add some improvements to improve the reliability and efficiency of the algorithm.But today, time is passing and the important thing, for me, is to understand the basis and if he gives us time it is clear that I would love to introduce improvements!

However, tomorrow at 11am we have another meeting since in the other meeting we said that I would calculate the distances, sort them in ascending order, establish the mode for several test patients and, finally, calculate the statistics of the algorithm which would be specificity, accuracy and sensitivity.

Once I had it all done, yesterday afternoon, I sent it to him and, unfortunately, Dr. “x”, Ph.D. has found something that is not quite right. So, tomorrow we will meet and, for sure, we will fix it!

I have done two mails to him so that he can go doing something for tomorrow; I know a little of serious to have done badly everything and the hours that I spent the day before; Nevertheless, Dr. “x”, Ph.D. has preferred that I do not touch anything and with these textual words has finished his mail "Do not touch anything, tomorrow we speak."

13-07-2021

Now I have finished the meeting with Dr. “x”, Ph.D.. It went better than I expected! I have understood how I have to set the fashion on each of the test

patients. I was doing it only for one patient and the result or, rather, the output pronounced by the algorithm was applied to all the other test patients. This is not correct because the mode will vary for each of the patients and it will be with the mode of each of the patients that we will see if the algorithm hits or misses in relation to the tumor class provided by the ICU data repository.

However, it has not been all flowers and violas. We have found ourselves in ties while measuring distances. We were very surprised; we are dealing with figures of at least 7 decimal places! Both Dr. “x”, Ph.D. and I are trying to find some mathematical function which allows us to break the tie since if we leave it as it is the algorithm is not able to decide between those which are with the same position; fact which makes it difficult at the same time to know which are the nearest neighbors to the proposed test patient.

Similarly, he has advised me to make some improvements in the statistics that will cause that if there is a change of data, these will be calculated. And so I have done so.

Now while waiting for a solution either from Dr. “x”, Ph.D. or from me to the problem of the ties, I will also focus on the written part of the work. I have already programmed the points and it should be noted that I have changed the 2nd part of the table of contents; thus, I will not talk about medicine but about the combination of IA with medicine in various areas such as diagnostics, imaging, drug development and treatment customization. At least for today.

Sincerely, I hope to be able to receive or find a solution soon on the ties; This issue puts me a bit behind in my programming.

14-07-2021

I bring good news! Dr. “x”, Ph.D. has managed to find a solution on the ties and now, I have finished making the algorithm applied to 20 test patients with your great input. I have made copies of each of the steps performed and maybe the document is more than 25 pages long.

However, I have done it this way because I find it easier to explain the process.

Honestly, I feel satisfied since, although I am still waiting for Dr. “x”, Ph.D.'s comment on the excel execution, the KNN algorithm gives me an accuracy of 95%. I think this is a very good result! :)

15-07-2021

Dr. “x”, Ph.D. hasn't gotten back to me yet, I don't want to burden her and will wait until Monday to see if she tells me anything about the KNN. In the meantime, I haven't been able to stop progressing; I've planned to read a chapter of Deep Medicine, the author of which is Eric Topol, and then advance one point per day of the research work written part. So far, I think I am on track with my planning. With this book I learn a lot of knowledge that I can incorporate into the work. So, I can say that this is a very helpful reading.

18-07-2021

It's 4:30am in the morning, today I woke up because of my father's noring. I can't sleep so I've decided to advance work. Only having slept 4h I feel active and in the mood to move forward.

However, whatever I do today I will review tomorrow; in case my faculties are not as good as I think. :)

Today I also asked “M” when we will meet and he suggested an online Meet in the morning at 19:00h. I'll let you know how it goes!

19-07-2021

After two hours of bottling, we filled 42 tomato jars with my grandparents. I'd say it relaxed me, it's the same thing every year. These jobs give my brain some air.

However, today I continue with my programming; this one does not stop and, as I said yesterday, now I am going to review everything I did and also read a chapter on the development of AI drugs. In this way, I will take notes
and then I will write the pertinent point to the document of the written part of the TdR. Come on, let's go for it!

20-07-2021

Today my goal was to finish item 5.3. Soon I will have to leave for camp and I would like to leave the work finished but above all very well done.

However, it's already seven o'clock in the evening and I still have a little bit left to finish it. That's okay! My mother and I are now going to paint our nails; a little distraction will also be good for my brain but the computer will come with me because in case we have to wait to paint them then I would continue with my project. ;)

(Moments after painting our nails)

And done, while we were waiting for each other, I discovered that there was free wifi so I was able to advance a lot and finally I ended up with pink painted nails and the point more than finished! A success!

21-07-2021

For today I thought of including a sub point within 5.3 to conclude how AI is the master key to achieve personalized medicine.

After having explained what process is being carried out today, the problems it presents as well as showing the steps that will be followed in the procedure of personalized medicine that is expected to be achieved in the future, I see the need for a conclusion where AI is the star.

25-07-2021

Good morning! I have finished writing all the points and, with much satisfaction, I can say that only the conclusions are left! I am happy because I see the end of this project from a very enlightening and hopeful point of view at the same time. I like the way I have organized myself and see how the work is paying off!

26-07-2021

Today I received the best news! Dr. “x”, Ph.D. has confirmed to me that the algorithm is well done and she has invited me to her laboratories at the University to see it and even to elaborate another algorithm. I am very, very happy! And of course I will accept the challenge of building a new algorithm and, of course, the experience of getting to know some mathematical laboratories!

27-07-2021

Today I have finished writing the conclusions of the research work, I just need to know where the acknowledgements go; I doubt if they have to go in the introduction or in the conclusion; beginner's doubts, ups!

To my to-do list for today, I also have to answer Dr. “x”, Ph.D.'s mail since I'm looking forward to it! I will thank her for the opportunity and I will thank her in all my heart. Also, today at 19:00h I have a meeting with “M”, my tutor. I guess we will talk about the improvements we can make to the already finished work. However, I would like to read it from head to toe to finish some points.

14-08-2021

I'm here again! I came back from the colonies in Girona, with Covid for that reason, on August 9; in spite of this, the conditions in which I find myself make it a little difficult for me to carry out the improvements of the research work.

However, I feel much better than the first days; so for today my goal is to improve the whole point 4, including also its subsections. In this improvement, I will make sure that by reading the paper I will be able to understand all the content without the need to search for anything in the browser.

In this way, I will do it with all the points included in the work; but, for today, I have enough with point 4. It is a section that requires mathematical knowledge and a lot of theoretical basis.

15-08-2021

There are approximately three days of confinement left. I have noticed that I have completely lost my taste and smell. I hope to get it back soon, sincerely.

For today's programming I plan to improve all of point 5 and make sure that all quotes are heavily referenced and that the lives of the authors of the quotes have been briefly explained.

16-08-2021

Today I've finished the improvements of the TdR. So, it is planned to improve both point 6, that of the explanation of the practical part and point 7 of the conclusions.

After reading and re-reading the whole point 6, I see no problem understanding the procedure that I have followed for the elaboration of the algorithm; although I understand that if a person does not know what the subject is about, he/she can get lost easily.

17-08-2021

With only one day left in confinement, today I think I will proceed with the creative design of the work; the cover page. I have some ideas but still a bit fuzzy.

Currently, I am painting a picture of the entrance at the Eiffel Tower, hopefully it will give me creativity. However, the basic idea I would like to capture on the cover is an equal union between humans and Artificial Intelligence since together we improve our healthcare system, not to mention our lives!

Well, tomorrow I will explain where this idea has taken me.

18-08-2021

Even though I didn't expect it, I finished the cover of the paper yesterday! I kept the initial idea which consists of a human hand holding the choir, symbolizing life, and a robotic hand reaching out to help, to facilitate, to improve this life.

For today's programming, I plan to correct some structural aspects of point 6 that deals with the explanation of the practical part.

01-09-2021

Good morning! Now I have arrived home after spending the day at the Universitat Rovira i Virgili in Tarragona.

First of all, my mother and my brother have joined me in his office and I have thanked her for all she has done throughout this research work for me and, in addition, I have given her a present as thanks. She was very happy and so was I!

When my brother and my mother left, Dr. “x”, Ph.D. showed me around the university. All the classrooms were closed, but we were able to enter the laboratories, where I stayed to work on the algorithm.

In this one, there was no problem or difficulty. We based ourselves with the same criteria of the KNN algorithm and I can affirm that it has been very

entertaining to do this algorithm and to check that it has an effectiveness of 100%!!!!

However, I have sent Dr. “x”, Ph.D. an email to take a more representative sample to make sure of the result obtained. I am satisfied with the practical part; however, I am not sure whether to include this algorithm in the body of the paper or in the annexes!

While I was doing the algorithm, my mother and my brother went to the Carting of Tarragona and did a lot of races! They had a great time!

Once they came to pick me up, we decided to go to eat at a restaurant called Can Sala. My God, we had a great time! Everything was spectacular!

And, after an hour and a quarter drive we arrived in Deltebre! And you may say, what a busy day today “A”! And I would answer, yes, but we have not finished yet because my mother and I, after a year and a half without going, we decided to go to the hairdresser and we got a haircut.

And now you may ask me, “A”, are you going home now, right? And I'll tell you, there's nothing I'm looking forward to more but, the reality is that I have dinner with some friends I met in a camp, yes where I took the Covid-19, and I can't miss it because I'm a possible "premonitor" so... A very busy day today, but full of good emotions! I feel so happy with life! :)

04-09-2021

I'm getting to the final stage of all this work and just have the strings left to bind to get everything just right. However, right now I have a lot of open minds and I need to make a list to clarify my mind. So that's what I'm going to do first before I start with the conclusions that will close my Research Paper presentation.

30-12-2021

Saying goodbye to the year, I find myself on my terrace, tweaking as many details as possible so that everything is perfect for January 14, the final delivery of the TDR. My mind is full of illusion and ambition on this project; thanks to this project I think I have discovered my purpose in life and therefore my professional career.
Today will be the last day of this diary in which I have poured so many emotions, thoughts and truth. I can only feel grateful for all the people who have helped me along this path that I never thought would bring me so much progress.

Today, December 30, 2021, I finish this stage and send the work to the printer without any modification option. :)

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