UNIVERSITY OF LEICESTER

Triage NHS patients with AI

Data Analysis for Business Intelligence with a year in industry

by

Kanchan Varma

Supervisor

Dr. Evgeny Mirkes

Abstract

The role of technology in modern healthcare is increasing. It is utilised in acute and chronic care settings, in hospitals and in communities, and it can even be used to keep people from being sick in the first place so that we can all live longer, healthier lives. Every aspect of our lives has been controlled by technology over the last ten years, and healthcare is no exception. Healthcare automation is a sensitive topic, especially given the high demands placed on social intelligence and empathy in the medical field. There are times when technology can be utilised to support or help humans, even while in the field of medical care, it is true that we are a long way from completely replacing humans with it. The NHS's secondary care providers have begun using machines to anticipate ailments, but primary care is still far behind. The primary care area of the healthcare industry has adopted technology more quickly as a result of the epidemic.

The purpose of this dissertation is to develop a web-based application with a form that enables automatic triage of patients for accident and emergency cases or permanent medical issues that need constant surveillance should be reported to the relevant NHS department. (GP, Cardiologist, Gynaecologist, Clinical Pharmacist, Physiotherapist). The automated triage method can have an influence on the A&E service department and save the GP or other healthcare professionals important time that they would have otherwise spent manually evaluating each appointment request.

The primary goal of the research is to implement an artificial intelligence engine that employs natural language processing and IBM Watson technology to generate a series of questions based on patient input and to predict incoming patient requests for the appropriate departments using machine learning algorithms with multi-label classification, such as Support Vector Machine (SVM), K-Nearest Neighbours (KNN), and Gaussian Naive Bayes (GNB). Each of these models has been highly modified to enhance performance. The KNN classifier, the algorithm that worked the best, is linked with the UI for the computerised system.

When utilised for multi-class prediction together even the least accurate models in this study indicate tremendous potential when employed with free-text labelled data as opposed to categorical data with labels. Applying this automated method to the medical area requires pre-training the model on labelled data. Despite the automated system's machine learning and deep learning aspects not having been taught on real healthcare data since real time isn't available, synthetic data is generated using different resources, and the final dataset is in the form of questions based on patient's diseases, the model would perform the same if trained on relevant data, whether category or free-text, both of them.

Acknowledgement

I want to express my gratitude to my academic supervisors, Dr. Evgeny Mirkes and Director Dr. Andrew Morozov, for their continuous support and guidance throughout this journey. It would not have been possible to conduct this research without their cooperation and assistance.

I express an abundance of gratitude to Daniel English, my industrial supervisor, who has been courteous and incredibly motivating me over the past ten weeks. I could not have done this without him. I also want to thank Uniworx for providing me the chance to work with NHS for this project.

I am forever obliged to the Department of Mathematics at the University of Leicester for offering me with the foundation and learning opportunities I needed to finish my research effectively.

I want to thank my family and friends for their everlasting love and support throughout this difficult time. I want to express my gratitude to all of my friends for their assistance and support during this challenging academic year.

I want to extend a particular thank you to Pranav Varma for being with me throughout this journey. Without his inspiration and encouragement, I never would have finished my master's degree.

Contents

List of Abbreviations

NHS – National Health Services

PCN – Primary Care Network

GP – General Practitioner

ML – Machine learning

DL – Deep learning

NLP – Natural language processing

AI – Artificial intelligence

SVM – Support Vector machines

KNN- K Nearest Neighbour

GNB- Gaussian Naïve Bayes

GDPR – General Data protection regulation

List of Figures

1.Introduction

The NHS 111 service, which replaced the NHS Direct service in England, aims to help members of the public who require urgent medical assistance. A referral to a primary care facility is the triage outcome in about 55% of calls to the NHS 111 call service. Patients may phone 999 or go directly to emergency departments (EDs) if a timely service, defined as a primary care contact within the time period stated as part of the triage outcome, cannot be offered. As of last time, 47.6% of 111 callers who were directed to a primary care provider made contact with that service as their first port of call.

The healthcare system is funded public by UK (United Kingdom) known as the National Health Service (NHS), offers inhabitants a full range of medical treatments at no cost at the point of use. In 1948, the NHS, one of the largest and most established single-payer healthcare systems in the world, was established on the idea that usage of premium services should be available to everybody healthcare, based only on clinical need rather than financial means. Its primary value maintaining the principle of prioritising patients. The service's initial focus was on disease diagnosis and treatment. It now contributes more and more to both preventing illness and enhancing the general public's physical and mental health.

Many diverse organisations that specialise in various patient care make up the NHS. Every 36 hours, more over 1 million patients are served by these services combined. 'Primary care' professionals ought to be contacted first in situations that are not emergencies if there are any worries about a person's physical wellness. These professionals include physicians (GPs), in along with dentists, optometrist and chemists (for prescription drugs and medical advice). There are about 36,000 general practitioners in England, and they work in more than 8,300 practises. For acute conditions, patients can visit an urgent care centre, such as an accident and emergency department.

The staff of Physician practises strives to provide regional solutions to problems, including by providing solutions unique to the practises. If a patient's condition requires more specialised treatment or further investigation, they may be referred to another healthcare provider. These might be found nearby or in a medical facility. Patients are entitled to choose the various treatments and service providers they get (whenever it practical). They should be encouraged to make the best decision for themselves. The majority of mild to moderate diseases and longer-term conditions are increasingly being treated in the community.

Many people are unable to schedule GP visits because of the workload and staffing crises. This affects people who need constant medical monitoring, like those with heart conditions. The primary care network was established to cater to the needs of individuals who require recurring check-ups due to chronic conditions. PCNs specialise in a range of chronic conditions, including mental health problems.

The NHS general practise is currently experiencing a crisis due to a variety of conditions, such as a lack of employees, an expanding workload, and financial challenges. Although the government has made several attempts to address these issues, nothing has changed.

The healthcare and medical industries are well known for their high paying professions and stability, not to mention the nobility factor attached to it, despite the fact that working in each field has its own set of benefits and drawbacks. Although doctors and surgeons are at the heart of the healthcare sector, administrators, managers, and technology all play crucial roles in essentially ensuring that facilities run smoothly.

Many of the technologies used in the initial phase of the pandemic were well developed but had not yet been extensively utilised. Due to the technology's maturity, remote consultation for medical care has become much more common and widespread recently.

However quickly digital technologies have recently been adopted, the health and care system is still in its infancy when it comes to digital health, with many tools simply copying physical methods and procedures rather than capitalising on their unique advantages.

Artificial intelligence (AI) is used in a wide range of industries to complete a number of tasks that can be computerised but would otherwise be completed by a human. AI offers a wide range of practical advantages, including lower operational and labour costs, automation of procedures and operations, improved dependability, and better productivity. Even if the efficiency and effectiveness gains this could bring to fast-paced, stressful A&E conditions could be enormous, the use of AI for medical reasons raises several ethical questions.

Numerous advantages could result from such a system, including less staff burnout, increased staff retention, decreased misdiagnosis, improved patient outcomes, and decreased negligence lawsuits.

This aim of this project is to develop an application that is designed to prioritise patients with the help of the form in order to reduce the general practitioners' heavy burden. This User Interface form is used to perform tasks like adding patients to a queue based on the patient priority. Examining symptoms entered by the patients to determine the severity of the problem and to set priorities. In collaboration with emergency services, the identification and treatment of urgent symptoms. Helping patients locate the best medical institution, whether it's an A&E department, a pharmacy, a GP, or another hospital division, it also provides simple medical assistance to patients.

Multiple datasets are used to generate a synthetic dataset which is used in this project as the data is not available and most of the dataset is confidential.

The solution to enhancing the patient through automated self-service responses and actions is Watson Assistant. Reduce the amount of time that medical staff members spend on administrative tasks. IBM Watson Assistant is used to fill out the forms for the patients visiting to A&E department and streamline the registration process with the purpose like medical history, symptoms, other relevant information for triage process. With the use of AI, completing various activities such as question responding, sentence prediction for the next one, text classification, and others, has been progressively simpler with the help of Watson cloud by IBM.

2. Background

2.1 Classification of A&E (Accident & Emergency) facility service

Class 1: These departments are frequently mistakenly thought of as an A&E service by the majority of people. They are substantial emergency rooms with complete resuscitation equipment for patients, including those who have had cardiac arrest, and a round-the-clock service managed by consultants. 124 NHS trusts for this facility, where the majority of attendances occur, are in operation.

Class 2: These divisions are consultant-led institutes for specialty illnesses including vision issues or issues with dentistry.

Class 3: Minor illnesses and injuries include stomach-aches, wounds, bruises, certain fractures, lacerations, infections, and rashes are treated by this section.

2.2 Ongoing Challenges within the NHS

Every accessible piece of data points to the fact that people who receive care through the NHS are more likely to pass away than people who would receive heart disease, stroke, or cancer therapy in the majority of other industrialised nations. In 2014, the UK's survival rates were lower than average for all the cancers that claimed the most lives and were the lowest of any comparable nation for colon and pancreatic cancer. The UK was shown to have lower survival rates for heart disease and stroke in 2016.

In order to comprehend why this might be the case, the 2018 study also examined the NHS's priorities, efficiency, and resources. This comprehension of the apparent issue necessitates an awareness of the potential differences between the NHS and other organisations in these areas. There are fewer MRI machines and CT scanners per person than in any other rich country, according to the OECD, and there is little evidence of any special inefficiency in terms of administrative expenses, such as tax-funded. The UK's health service has historically had minimal capital expenditures, which is reflected in this.

Patients are having to wait longer for ambulance and emergency rooms as an outcome of a range of factors, including a rise in service demand and a constrained capacity to meet it. Crowding, greater demand for A&E services, and a worse patient experience can all be caused by a high volume of visits to the emergency room. The increased strain more closely focuses on A&E departments correlated with the increase in hospital urgent procedures compared to with the increase in A&E visits. One of the most obvious measures of the number of patients who encounter long waits in A&E correlates with hospital bed occupancy 'trolley waits' in A&E departments, which refers to a prolonged wait between the choice of bringing the patient to A&E and these individuals who are actually admitted to a hospital bed. It is still difficult to locate and retain enough workers in medical emergencies and other crucial services. There are also complaints of a lack of nurses and doctors in specialties such acute general medicine. The inability rapid admission of individuals from emergency rooms or provision of A&E patients with professional guidance so they can be treated and discharged will result in longer wait times.

2.3 Identifying Automation Opportunities in the NHS

The opportunity to significantly improve across the NHS and Social Care, patient care, employee satisfaction, and operational effectiveness is enormous if RPA (Robotic Process Automation) and more comprehensive automation skills are implemented successfully and consistently. Automating tedious and staff members' time would be freed up to put their abilities to use on more value-added tasks and spend more time with patients if repetitive tasks like patient registration and data uploads were eliminated.

The use of AI in the health and care organization can be accelerated through automation as a transformation enabler. This technology can dramatically increase productivity and efficiency in the NHS and Social Care, free up capacity, and support elective rehabilitation.

AI-enabled personnel use technology to increase time spent with patients, improve treatment quality, and be more efficient. This adds value to patient care by making sure the proper doctor is consulted the appropriate moment, and that the procedure is done correctly the first time. AI empowered patients to manage their own care and care plans and gave them greater autonomy over their health and wellness. One major advantage of artificial intelligence is the time it saves medical practitioners that they may utilise to provide patient care. Time squandered on paperwork and reporting is a constant source of annoyance, whether it is used to chase down diagnostic records that might be accessed online via an automated system or to re-enter data for soloed systems.

2.4 Current Areas of Automation in the NHS

A ground-breaking invention that incorporated AI in primary care services for urgent health services was the NHS 111, which was first implemented in 2011. The system operates around the clock to give patients the greatest medical treatment and enables consumers to schedule urgent care appointments that are not life-threatening. When a patient calls NHS 111, professional advisors evaluate the patient and direct them to the best healthcare option based on their answers to a series of assessment questions. Callers who need care are sent to the proper speciality service or even a primary care provider like a doctor, chemist, or nurse.

Automated health check programmes, such as diabetes testing, hypertension assessments, and NHS Wellness Inspections and gynaecological exams, are being operated to streamline the process of contacting and reminding and boost patient acceptance of precautionary health measures. According to the data, the service was equally as successful in connecting with more low-income as it was in the wealthier half, patients in the less fortunate portion of the financial distribution. By utilising preventative healthcare, this helped to lessen health disparities. network, year 2022). The administrative costs were cut by 40% after switching to an automated health check programme. It not only reduced administrative expenses but also relieved the personnel of a burdensome administrative workload.

Another illustration of effective AI use in healthcare is the NHS Covid app. During the epidemic, primary care has stepped up to the plate to assist in helping providing proactive remedies to Covid-19 patients. The fact that PCNs were essential in England's battle against COVID serves as sufficient evidence that they are capable of reducing the workload placed on GPs. Additionally, PCNs have been successful in vaccinating a sizable portion of England's population over the previous two years.

The epidemic has accelerated the speed of the NHS's digital transition. The NHS has successfully automated a number of its departments during the past few of years. It is obvious that automation is more common in rehabilitation facilities as a result of the use of technology to help with the early detection of several high-risk disorders including cancer. It is now possible to use robotics and AI in surgery because to recent technological breakthroughs. In order to aid in the early diagnosis of heart problems, wearables have been developed. According to Thomas (n.d.), the storing of enormous amounts of medical data enables analysts to extract valuable data that can be used to advance patient-beneficial research. But it appears that the primary care sector is lagging behind in terms of adopting new technologies.

Online triage solutions are widely available, and they automate the triage procedure. In various regions of England's primary care networks, these automated tools are being evaluated and tested. To evaluate the advantages and drawbacks of such solutions, numerous case studies are being conducted. Among the automated consultation scheduling and triage response systems being tested are Sensley's "Ask First" and “AccuRx”.

3. Need of Electronic Triage System

- Based on the literature study and gap analysis, it is advised to employ an electronic system to evaluate patients' conditions remotely and electronically before deciding whether or not to admit them to the emergency department (ED). This will help minimise crowding and overhead in the ED.
- By keeping track of patients' medical histories and diseases with the use of technology like database management systems. Instead of having to ask the patient for the information, this will help in rapidly and accurately getting the needed data when it is needed.
- Instead of asking the patient a series of questions regarding symptoms they feel may not provide reliable findings, medical sensors can remotely recognise the patient's symptoms. It will also shorten the duration of therapy because the triage nurse in the ED won't have to look for any particular symptoms.

3.1 Specifications for the system

3.1.1 Operational Goals

- The system will permit entry in the format of textual and multiple-choice responses for every session inquiry.
- In a matter of minutes, the software has to connect an individual with the proper healthcare provider.

- The patient has to reveal the severity of the illness (whether it is urgent or not) and the purpose for scheduling at the moment of request.
- The application system will supply every relevant justification for the meeting.
- Depending on their symptoms or conditions, the computerised system will recommend straightforward medical remedies.

3.1.2 Non-operational Goals

- When tested on huge amounts of "test" data, the methodology must show a high degree of accuracy.
- The software's flexibility should extend to the inclusion of future updates.

4. Exploratory Model for the Demonstrator

4.1 Case Study Diagram

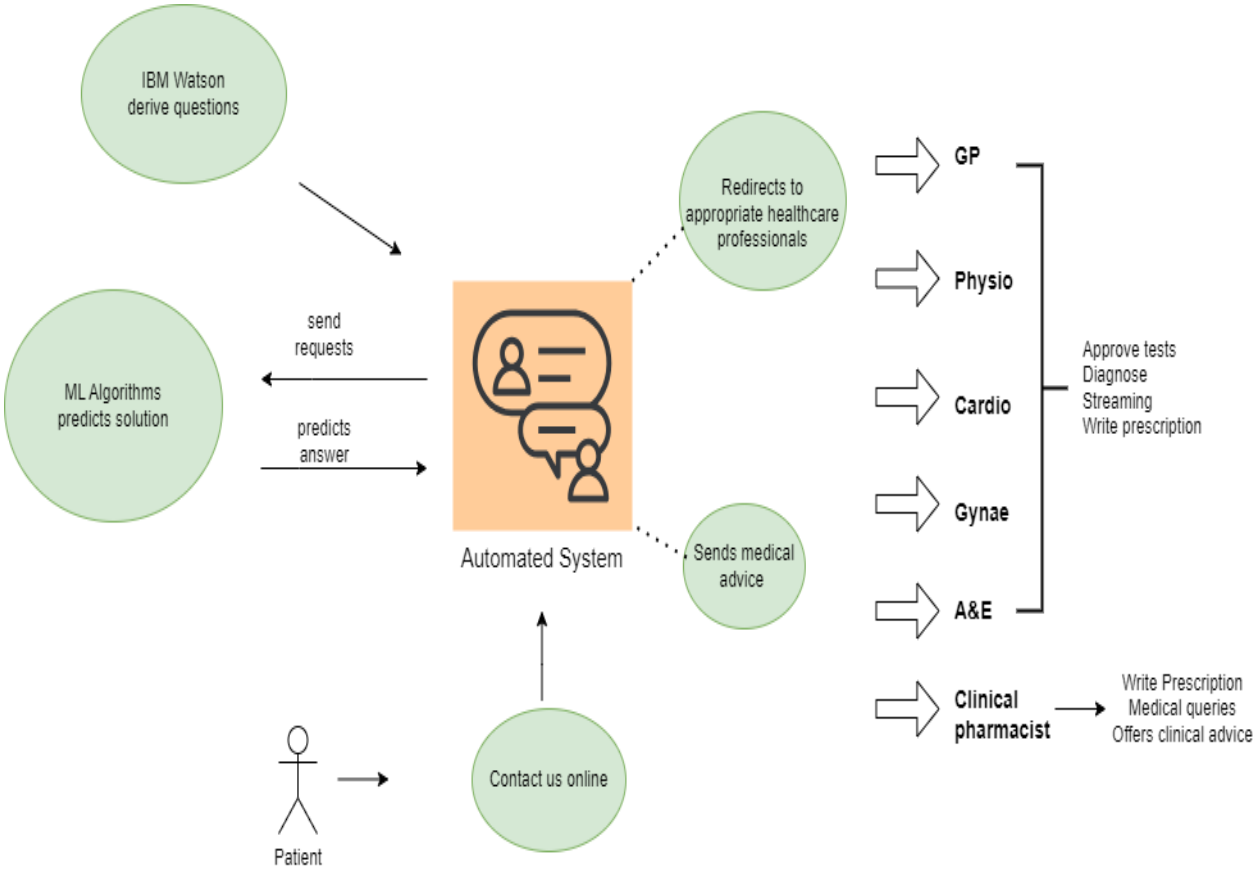


Fig 1: Case study illustration for E-lifecare automated system

4.2 Case Study Illustration

- **Patient:** Patient request for appointment by filling the form.
- **Computerised System:** This will ask a set of questions to patients which are multiple choice, free text or close ended(Yes/No) based on their input information the patient is redirected to the appropriate healthcare professional.
- **GP, Physio, Cardio, Gynae:** Physicians provide general medical care to patients, contributing to patient care, prevention, diagnosis, and treatment.
- **A&E:** A&E physicians are skilled in prioritize critical cases, stabilize patients, and make rapid diagnostic and treatment decisions.
- **Clinical pharmacist:** Clinical pharmacists may offer medication counselling, monitor for adverse effects, and contribute to medication management strategies.

5. AI Engine

5.1 IBM Watson

IBM's Watson is an AI system is designed to make your firm more intelligent and each employee their best employee. Advanced APIs, specialised tooling, and Software as a Service applications are all available in Watson. This suggests that Watson is made for sophisticated use cases and created to interface with software that professionals use on a daily basis. providing easy access to the knowledge you need in order to make the best decisions.

Deep learning, machine learning, and natural language processing are the foundations upon which Watson is constructed. IBM Watson employs NLP in various ways to understand and work with human language. The foundation model from IBM Watson NLP delivers advance analysis and comprehension of written content, enabling accurate data retrieval. IBM leverages Large Language Models(LLMs), It is specifically trained using a lot of textual information for NLP task which is widely used in healthcare domain. It empowers patients to quickly help themselves with simple queries.

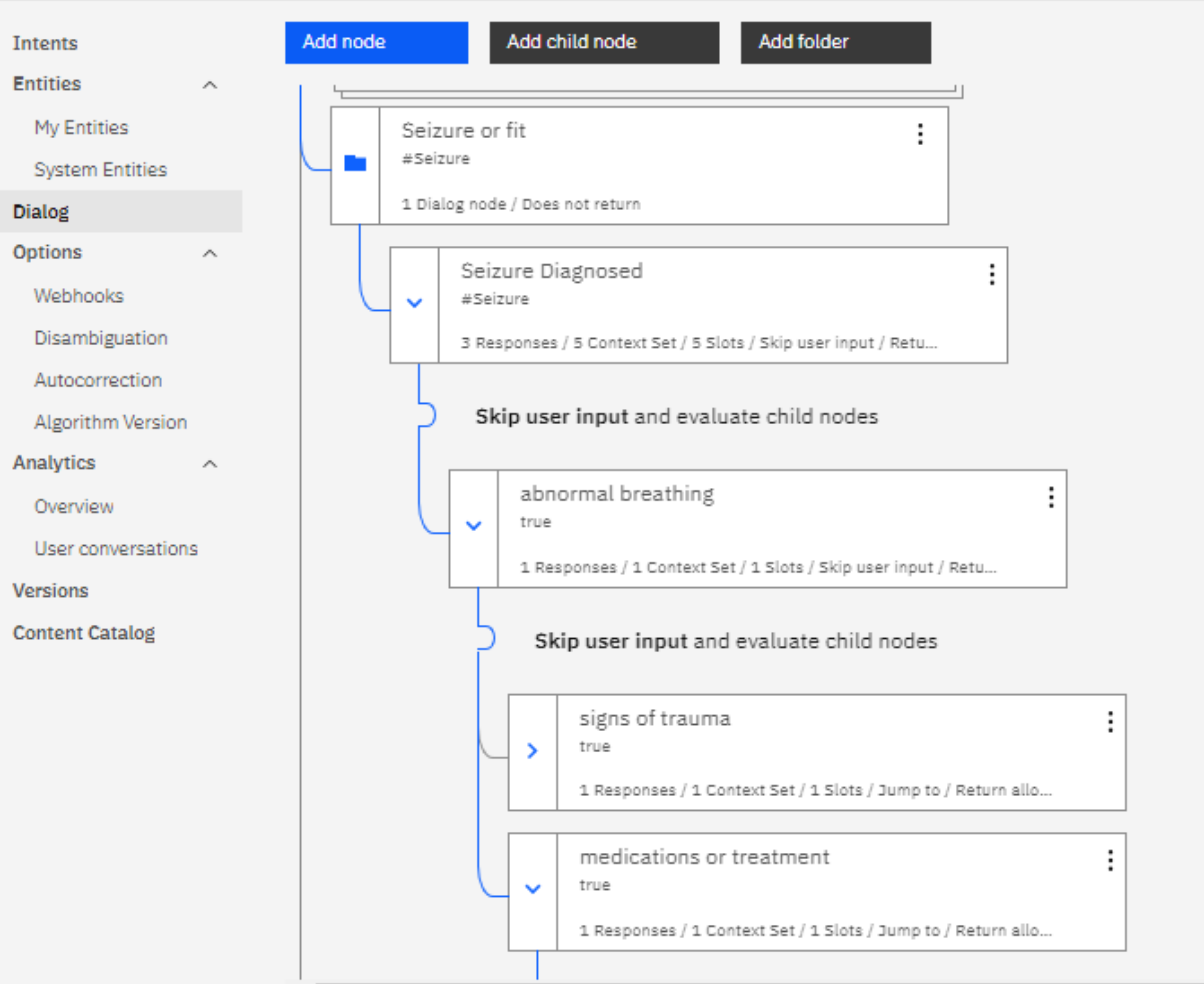


Fig 2: Dialog flow for seizure disease

This dialog flow is created by using all the four major algorithms of Watson, where intents and entities are created to process the flow of this disease and other dialog flow is created for fever disease.

Watson can analyse text data to determine sentiment, emotion & tone. It can have categorized text documents into predefined categories and topics.

In this project, I have used four major algorithm of IBM Watson, they are as follows

1. **Intent Detection:** Intent are purpose or goal that are expressed by user feedback, which could be a response to a query & processing particular task. IBM Watson can select the best dialogue flow to reply to the client's data by identifying the intent indicated by it.

2. **Entity Detection:** As Watson uses advanced NLP algorithm to identify entities such as people, gender, age, diseases. Once identified these entities can be used to classify and organize data, allowing system to gain valuable insights from their data.

3. **Irrelevance Detection:** This algorithm helps your dialog skills recognize subjects that you do not want it to address even you haven't explicitly taught it about what to ignore. It helps the flow to recognize when the request is widely off topic & redirect the conversation back into more relevant territory.

4. **Auto-correction:** It helps to auto correct your typos to avoid mistakes.

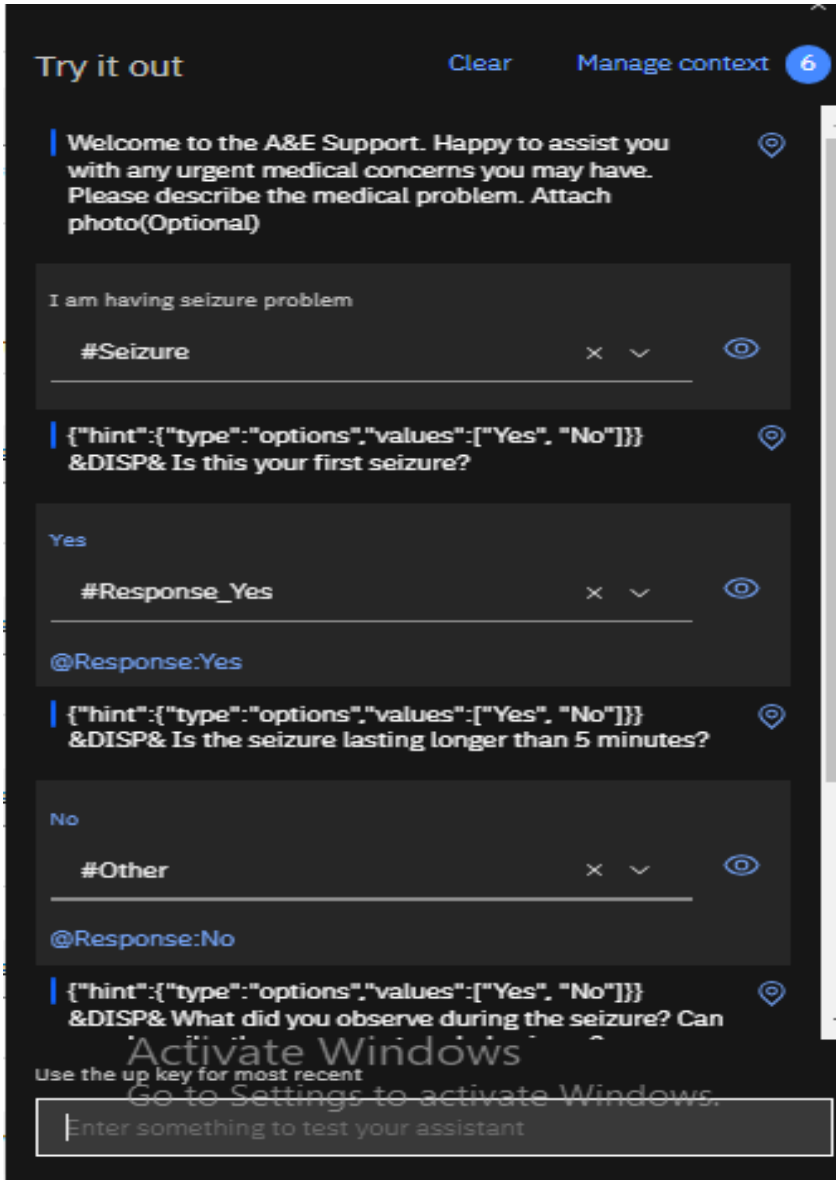


Fig3: IBM Watson Assistant

Watson has been applied to healthcare to analyse medical data and help clinicians in fields like oncology and radiology make diagnostic and treatment decisions. Ongoing research is being done to determine how Watson's aptitude for NLP, proposition subsequent ones, and based on research education could benefit health care decision support systems.

6. Angular Java Script Framework

I carefully considered a number of different User Interface Framework like React, although React and Angular are both popular JavaScript libraries/frameworks used for building user interfaces, but they have different philosophies, architectures, and use cases. How Angular would best serve the objectives to my project, before deciding to use it as my main UI framework. Because of Angular's extensive feature set, the reputation of its developer community, and its compatibility with the goals of Triage in Health Care industry, I chose Angular JS UI framework. I think Angular gave me the tools I needed to build an application that is strong, scalable, and user-friendly and meets or surpasses the needs of my project. This selection demonstrates my dedication to provide a top-notch solution that not only meets but also exceeds the requirements of my project.

Angular Java script is an open-source framework for front-end web development, it features excellent support and capabilities for building online applications. The Google Angular team first made it available in the year 2010. It offers better strategies for creating web applications and is a framework that is always evolving and growing. In order to construct apps, it primarily uses the model view controller (MVC) idea and supports both the dependency injection and data binding features.

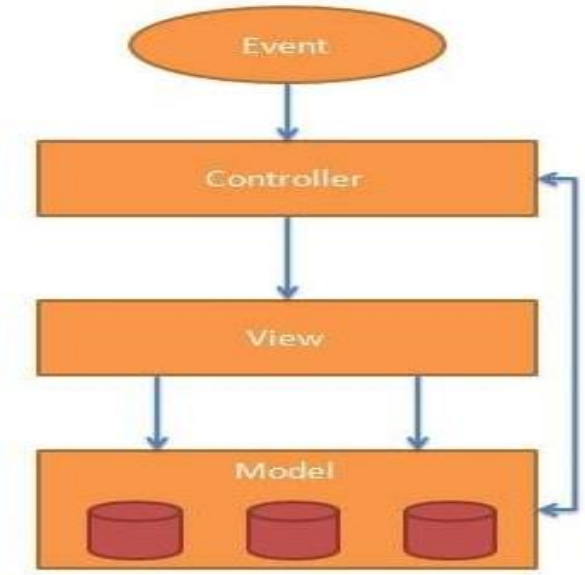


Fig 4: Angular JS MVC Architecture

Model View Controller is an acronym for MVC. It is a pattern for designing software that is used to create web apps. Because it facilitates separation of concerns and isolates the application logic from the user interface layer, it is particularly well-liked. This pattern is made up of three parts:

1. **Model:** The model is in charge of overseeing application data. It updates itself in response to requests from the view and directives from the controller.

2. **View:** The View is in charge of showing the consumers either all of the data or just a subset of it. When the controller decides to show the data, it also specifies the data in a certain format. They are template-based scripting languages like JSP, ASP, and PHP that are very simple to combine with AJAX technology.

3. **Controller:** The relationship between models and views is under the controller's control. It reacts to user input and interacts with the items in the data model. Following input validation and business actions that change the state of the data model, the controller receives input.

6.1 Benefits of Using Angular JS Framework

- **No prerequisite required:** AngularJS is designed to be compatible with HTML, CSS, and JavaScript. No need to learn a new scripting language. Furthermore, even if you don't already know them, HTML, CSS, and JavaScript are rather easy to learn.

- **Simple to expand:** HTML's functionality may be extended by coupling a certain behaviour due to a number of built-in features. Since anyone can add their own instructions to it, it is customizable.
- **Excellent MVC:** Many frameworks require the code to be divided up into discrete Model-View-Controller (MVC) components (Model, View, and Controller) in order to implement the Model-View-Controller (MVC) architecture. In Angular, the procedure is entirely automated. Programmers can save time by organising their code with Angular.

- **Simple for Testing:** JavaScript, a dynamically typed language, is used to create Angular. The ability of angular to express oneself is enormous. But Angular does not include a compiler. As a result, a reliable test code must be written for it. Unit testing will be significantly easier because dependency injection is already included. Unit and system tests can both be used with Angular.

Applications can provide interactive experiences where the display dynamically changes in response to model changes by using data binding. As a result, programmes can update themselves dynamically without having to reload the page. For instance, AngularJS synchronises these changes between the presentation displayed in the browser and updating the underlying data in the model at the same time. This results in a website with capabilities far beyond those of static HTML.

7. Natural Language Processing and Machine Learning for Classification

Machine learning models belong to a class of prediction models that are highly suited to improve emergency room procedures. They are especially strong because they can process many of different factors, learn intricate relationships and statistical patterns between them and related outcomes, and then predict patient outcomes with extreme accuracy. The extensive research on machine learning's applications in healthcare shows the possibility for employing these models to guide clinical care and offer high levels of personalisation. Due to the high level of assurance required by the healthcare industry, explainable machine learning in particular is receiving attention.

Since we are aware that the machine must learn, "machine learning" actually refers to "machine teaching." As a result, our responsibility is to develop a framework for learning and supply the machine with properly formatted, pertinent, and clean data.

When we refer to a "model," we mean a mathematical representation. Key is input. The knowledge that has been gleaned from training data makes up a machine learning model. The model evolves as more knowledge is gained. A machine learning model may evaluate a case using its prior "learning" and generalise to deal with novel situations. The objective is to create an environment where the model improves at the task over time that is given to it.

To automate unnecessary tasks, this can be helpful. We need to teach the computer how to automatically learn and get better without being told to in order to automate the triage processes. We make use of machine learning models for this.

It is possible to develop automated systems with the ability to learn from experience by fusing machine learning and natural language processing. The next part provides an explanation of some of the most popular machine learning models as well as natural language processing for categorization issues.

7.1 Multi-label Classification

Using data generated for this project and considering the complexity of service departments as labels in order to anticipate difficulties, we used a multi-label classification (MLC) model. three service departments at once and then made use of understanding the relationships between the obstacles to further raise the accuracy of the predictions. However, the machine learning community has recently begun to show an increasing amount of interest in multi-label classification (MLC). A few publications offer empirical comparisons of MLC approaches while others provide assessments of the datasets and methods used in MLC. They only take a small number of methodologies and datasets into account.

Algorithm adaptation approaches, as opposed to problem transformation methods, explicitly adapt some current multi-label instructional setting is used for developing programmes. Text classification uses specialised algorithms and trained models to identify and classify unstructured text input into predetermined categories in order to anticipate the category of unidentified text. We contrast a few illustrative approaches, which are thoroughly described in the parts that follow.

Now I have implemented Linear SVM algorithm to python. Here, I have used the synthetic dataset which is in the form of questionnaire in the form of text and categorical for Seizure and Fever disease. This same dataset will be used to implement in KNN and Gaussian Naïve Bayes algorithms.

7.2 Support Vector Machine

Support Vector Machines are supervised learning tools for pattern identification and regression that are based on statistical learning theory. Certain simple types of algorithms can be learned successfully using statistical learning theory, but more complex models and algorithms (like neural networks) are typically required for real-world applications, which makes it much more difficult to theoretically analyse them. SVMs can be thought of as being where learning theory and practise converge. They create models that are intricate enough to be analytically studied (by including a broad class of neural networks, for example). The reason for this is that an SVM can be viewed as a highly dimensional linear approach.

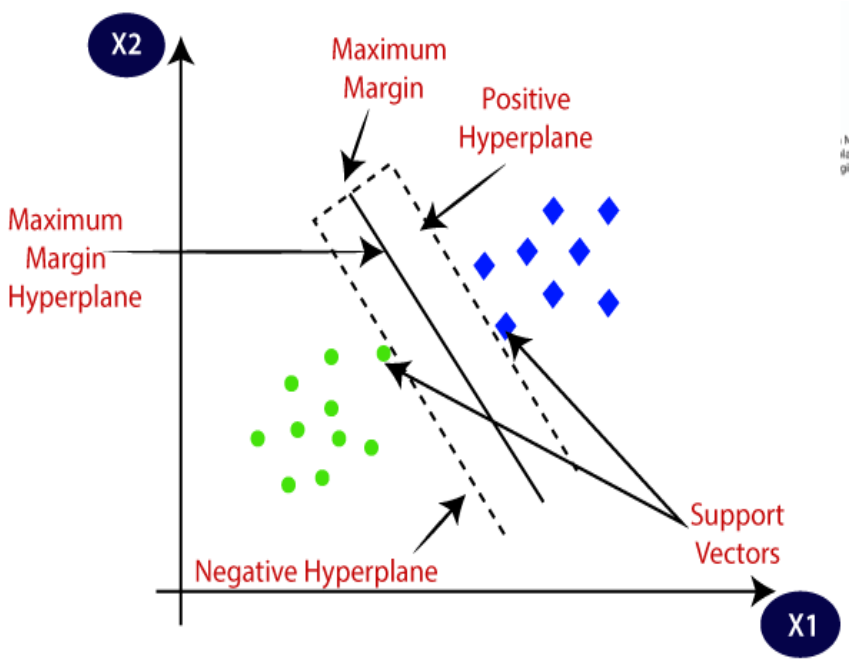


Fig 5: SVM Classifier

The most prominent SVM is used to choose the vectors and points that contribute to the hyperplane. Support vectors, which are used to express these extreme scenarios, are the foundation of the SVM technique. Look at the image below, which separates two objects using a decision boundary or hyperplane distinct groups:

Linear SVM: The phrase "linearly separable data" describes information that a single vertical line can be used to divide into two distinct groups. Linear SVM is used to categorise this type of data, and the method used to do so is referred to as a linear SVM classifier.

Non-linear SVM: Non-Linear SVM is used for irregularly divided data, which means that a dataset is non-linear if it is unable to be categorised using a line that is parallel and requires the employment of a non-linear SVM classifier.

SVM is best for small datasets. It is known for its effectiveness in separating data points with clear margin which is beneficial for multiclass classification. Linear SVM is powerful and versatile, known for its high dimensional space, robustness to outliers and strong generalization.

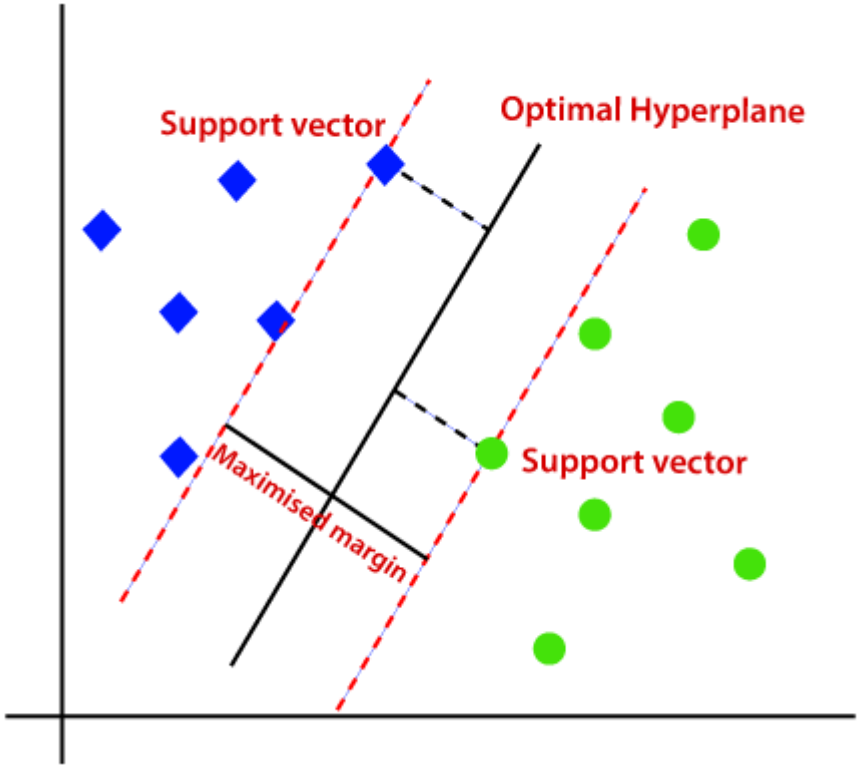


Fig 6: Linear Support Vector Machine

7.3 K-Nearest Neighbors

The K-NN algorithm is a notable example well-known text classification algorithms and is regarded as a well-known pattern recognition technique. One of the basic machine learning techniques for classification, supervised learning is the foundation of the K-NN algorithm.

By assuming independence, KNN used for small datasets, simple and widely used for multi-label classification, it does not get impacted by outliers.

7.4 Gaussian Naive Bayes

The assumption that each class's continuous values are distributed in accordance with a normal (or Gaussian) distribution is frequently used when working with continuous data. The likelihood of the traits is dependent upon

$$P(x_i|y) = \frac{1}{\sqrt{2\pi\sigma_y^2}} \exp\left(-\frac{(x_i - \mu_y)^2}{2\sigma_y^2}\right)$$

Sometimes assume variance

- is independent of Y (i.e., σi)
- or independent of Xi (i.e., σk)
- or both (i.e., σ)

The Gaussian Naive Bayes model incorporates continuous valued information and models them as each having a Gaussian (normal) distribution.

GNB is simple and easy to implement, efficient for high dimensional data and small dataset. It requires low training time and handles categorical and continuous data.

8. Process flow

8.1 Objectives & Requirements

The main objective of this project is to capitalise on artificial intelligence (AI) to increase the effectiveness of accident and emergency (A&E) departments in healthcare facilities and decrease waiting times. The main goal is to improve the whole patient experience in A&E by lowering wait times, allocating resources optimally, and enhancing the quality of patient care. Data has been collected and integrated to generate synthetic data from several sources inside the hospital, including as admission logs, triage data, patient records, patient scenario bases on diseases, and historical A&E wait time data. I have used machine learning models and AI algorithms to analyse the gathered data and estimate A&E demand, patient flow, and wait times. Use AI to forecast A&E visit trends, peak times, and seasonal fluctuations in patient arrival patterns. This aids in the proactive allocation of resources and scheduling of personnel. Create AI-based queue management systems that track and control patient lines, ensuring that patients receive prompt attention from medical professionals.

Make that the project complies with all pertinent data security and patient privacy laws, such as HIPAA in the US or GDPR in Europe. Monitor the performance of the AI systems and algorithms on a constant basis, and make the required corrections to increase precision and effectiveness. By lowering wait times, fostering better communication, and ensuring that patients receive the necessary care quickly, put your attention on boosting the overall patient experience.

In conclusion, the project's goal is to employ AI to improve the efficiency of a number of A&E department procedures, including resource allocation and triage processes. The initiative will ultimately improve patient care, decrease A&E wait times, and increase the effectiveness of emergency medical services by satisfying these requirements.

8.2 Data Collection and Pre-processing

Real-world data frequently has inconsistencies, is incomplete, and is more likely to have typographical errors. Data pre-processing is a technique that aids in cleaning and preparing data to aid classification algorithms. Synthetic data is created in the form of questionnaire based on patient's real time scenario for different diseases with different symptoms.

The Data pre-processing is carried out by applying steps to make the data more suitable for datamining. This steps are mentioned above in the process flow. After importing the libraries and loading the data, we executing the codes for data pre-processing and cleaning the data. To learn more about the data, I will investigate it. We can see that the data set contains 263 instances and 11 variables. The dataset has 11 variables, as can be seen. One discrete variable and ten continuous variables. Target_class variable is the discrete variable. It serves as the target variable as well.

8.3 AI Platform IBM Watson

IBM Watson AI Engine is used to derived questions based on patient input so that patient will be redirected to appropriate service department. Watson is an AI system is designed to make your firm more intelligent and each employee their best employee. Advanced APIs, specialised tooling, and Software as a Service applications are all available in Watson. This suggests that Watson is made for sophisticated use cases and created to interface with software that professionals use on a daily basis. providing easy access to the knowledge you need in order to make the best decisions.

8.4 Data Modelling & ML Algorithms

Data modelling and machine learning techniques are essential for reducing A&E (Accident and Emergency) wait times using AI. Machine learning models are trained and validated using the generated synthetic data. Data collection is cleaned, processed, and transformed. This could entail coding categorical variables, addressing missing values, and normalising numerical data. Make use of the data to extract pertinent elements that can help machine learning models produce precise predictions. You can determine hourly, daily, or seasonal trends in A&E visits, for instance in future scope. To acquire insights into trends, patterns, accuracy, and confusion matrices, visualise the data. This can aid in determining the causes of prolonged wait times.

To increase the precision of triage judgements, use machine learning models that analyse historical data and patient symptoms. This guarantees that urgent cases receive the attention they require.

The project can successfully employ AI to reduce A&E wait times, improve patient care, and guarantee more effective resource allocation in emergency healthcare services by putting these data modelling and machine learning methodologies into practise.

8.5 Integration of AI, ML with User Interface

- **Install Dependencies:** The required Angular packages and libraries, such as Angular CLI, Type Script, and any other requirements particular to my project, have been installed in my newly created Angular project. I wrote the script for the web-based UI in the visual studio environment.

- **Create UI Components:** For the Angular UI components that will communicate with the AI engine and machine learning algorithms, I had to design and construct them. These elements may include displays for showing results, buttons, input areas, and forms.

- **IBM Watson Integration:** I used the Watson APIs and SDKs to incorporate IBM Watson's AI engine. Depending on the backend technology, which is a Python Jupyter Notebook, I have installed Watson SDKs for Node.js or Python. With the help of these SDKs, I can communicate with Watson services that I'm using for this project, including Watson Assistant and Watson Natural Language Understanding.

- **Backend Development:** To handle communication between the frontend (Angular) and the AI engine (IBM Watson), I have created a backend server. The backend acts as a middleman for processing responses to API requests made to Watson services.

- **API Endpoints:** I have developed RESTful API endpoints on the backend that provide the IBM Watson capabilities required. It will produce endpoints for sending and receiving messages same like I do when using Watson Assistant for chat bots.

- **Authentication and Security:** Protect sensitive data by implementing authentication and security measures, and make sure that only authorised individuals can access the AI engine and machine learning features.

- **User Interface Design:** Connect the UI elements to your Angular application to create a seamless and approachable user interface for engaging with the AI engine and evaluating machine learning results.

- **Deployment:** Deploy the backend (server with AI and machine learning integration) as well as the frontend (Angular app E-Lifecare a Triage form) to your hosting environment. Make that the application is scalable and safe, and that all dependencies are set up correctly.

8.6 Interpretation of the Results

A comprehensive analysis of a number of variables, including as wait time reductions, patient satisfaction, resource optimisation, and clinical outcomes, is required to interpret the findings of an AI project aimed at reducing A&E wait times. The interpretation should concentrate on fulfilling the project's goals and raising the standard of emergency medical care in general.

9. Methodology

In order to approach the problem statement, the methodology pipeline listed below is applied.

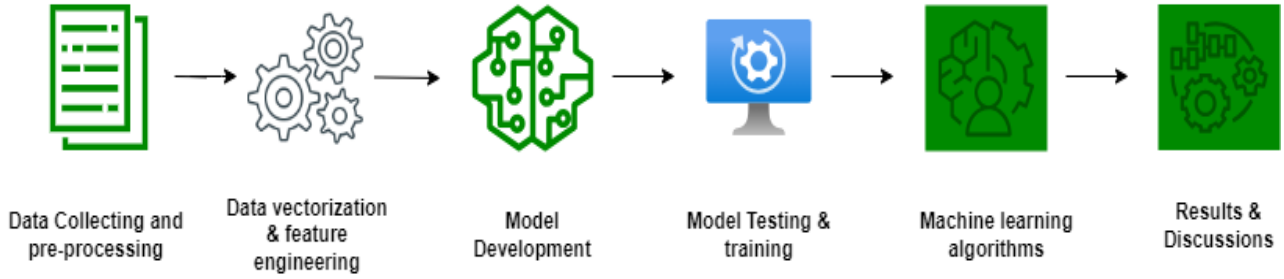


Fig 7: Data Science Life Cycle

9.1 Data Collection and Pre-processing

9.1.1 Data Collection

With the aid of healthcare portals like WebMd and NHS, the collection of data needed for the research was created. Synthetic data is created in the form of questionnaire to redirect patient to particular queue based on their symptoms, medical history for these two diseases- Fever, Seizure(fit)

Real-time data is not available due to GDPR and data privacy concerns, so synthetic data has been produced for model construction and analysis. The artificial data was created by developing a series of questions based on the many patient situations that gather the information required for assigning patients to distinct diseases like fever, seizures or fits, difficulty breathing, and sudden rapid swelling. The questions are written in such a way that the automated system can direct the patient to the proper facility based on a pattern in the type of answers provided. By selecting a group of disorders, followed by developing relevant follow-up questions, the initial dataset was created. The dataset is updated with each response to these questions as an entry, along with the relevant label.

For the purpose of gathering data, it is presumed intended that the appropriate specialty, rather than the GP, should be consulted for the prolonged diseases. It is thought that patients should go to a pharmacy for diseases that have developed within the last 24 hours for fever or longer. Emergency care should be considered for chronic or sporadic illnesses. To determine whether a seizure is caused by a disease, injury, or other condition, look for any

warning indicators. The patient is guided to gynaecologists, GP, etc. based on the symptoms they exhibit.

For this analysis, I used two separate datasets. GPs were the most commonly occurring label in the initial draft of synthetic data for fever disorders, which had 263 rows and 11 occurrences of data skewed in that direction. The same 263 rows and 11 cases can be found in the second draught for seizure illnesses. The accuracy of the model would be significantly impacted by the bias towards the most frequent label that training with this dataset is certain to produce.

In order to prevent bias during training, the following data draughts were constructed with a balanced set of data. A more generalised questionnaire that is suitable for the majority of the circumstances addressed by this project has replaced the original, highly specialised survey that was employed to gather the information.

The following are some questions from the new survey that apply to the majority of conditions:

1. Are you suffering from high or mild fever? (High/Mild)
2. Do you have a cough, sore throat, runny nose, or other respiratory symptoms? (Y/N)
3. Is there a recent history of travel to endemic areas? (Y/N)
4. Is this your first seizure? (Y/N)
5. What did you observe during the seizure? Can you describe the movements or behaviours? (Text)

The dataset is saved as a csv (comma separated value) file and has about 264 rows of data for fever same is created for seizure disease. Figure shows an illustration of the dataset.

SrN	medical problem	Are yo	Are any o	Do you h	How long you are suffering f	Is ther	Are yo	Have you	Do you ha	Have you	Do you	Age_Band	Gen	Conclusion
1	My body temperature is	Mild	Yes	No	Longer than 24 hours	NA	NA	NA	NA	NA	NA	65-84	M	Clinical Pharmacists
2	My body feels achy and I	High	Yes	Yes	Long term or intermittent	No	Yes	NA	No	Yes	NA	18-24	M	GP
3	I'm running a fever or ma	Mild	Yes	No	Long term or intermittent	Yes	NA	NA	NA	NA	NA	65-84	F	Clinical Pharmacists
4	My temperature is above	High	No	Yes	Long term or intermittent	No	No	No	Yes	NA	NA	25-44	F	A&E
5	My body temperature is	High	Yes	Yes	Long term or intermittent	No	No	Yes	NA	NA	NA	18-24	M	GP
6	My forehead feels warm	Mild	Yes	No	Less than 24 hours	NA	NA	NA	NA	NA	NA	85+	F	Clinical Pharmacists
7	I'm feeling hot and swea	High	No	Yes	Longer than 24 hours	NA	NA	NA	NA	NA	NA	65-84	M	Clinical Pharmacists
8	I am having a flu like syn	High	Yes	Yes	Long term or intermittent	No	Yes	NA	No	Yes	NA	45-64	M	GP
9	I'm running a fever or ma	Mild	No	Yes	Long term or intermittent	No	Yes	NA	Yes	NA	NA	65-84	F	A&E
10	My body temperature is	High	Yes	No	Less than 24 hours	NA	NA	NA	NA	NA	NA	25-44	M	Clinical Pharmacists

Fig 8: Final dataset for fever

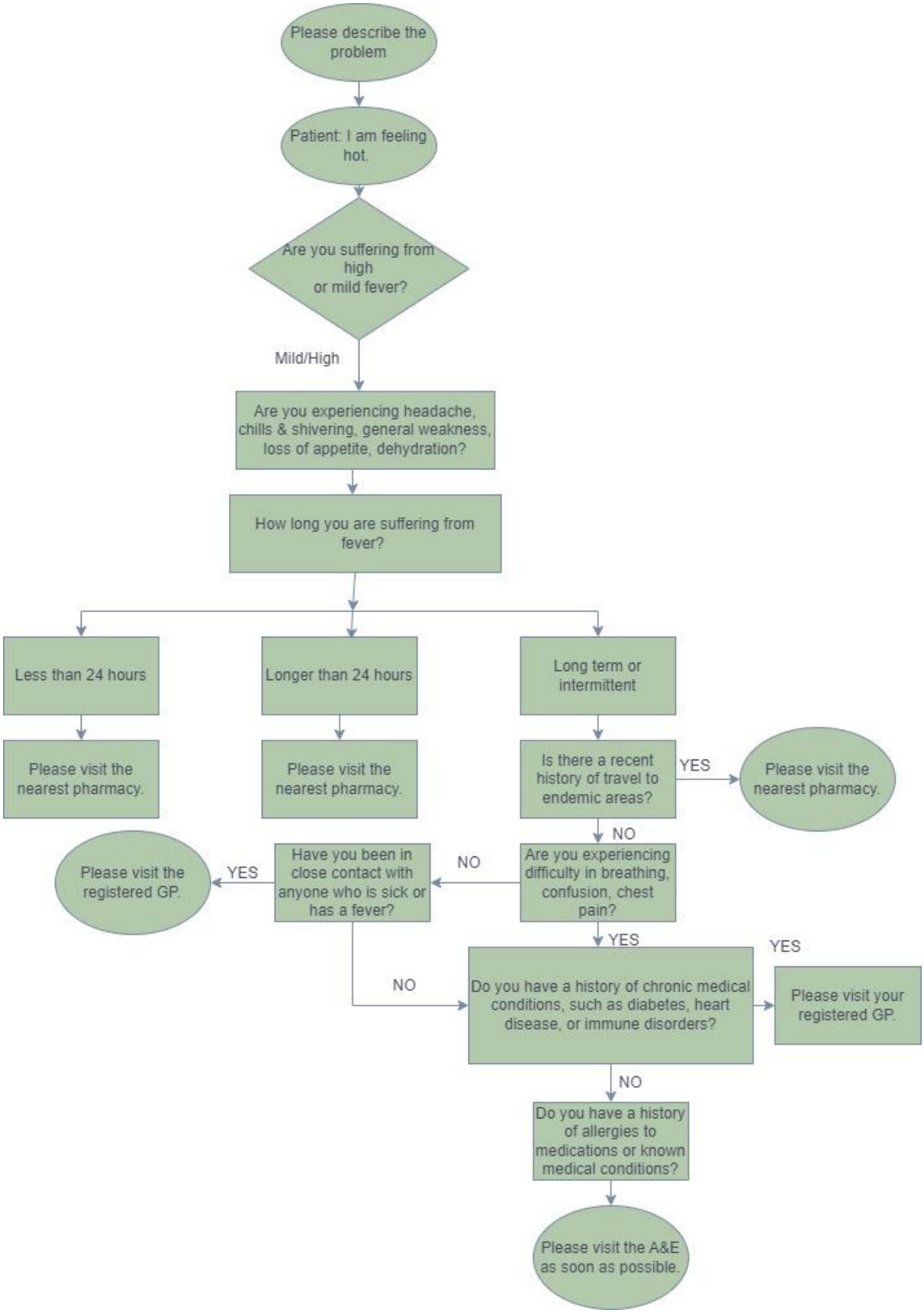


Fig 9: Structural outline of questions

9.1.2 Data Pre-processing

The data is examined to see whether any values are missing during the data pre-processing stage. The need for cleaning and pre-processing the dataset has significantly diminished since it was generated. There were hardly any missing data at all—not enough to affect the model's accuracy.

- **Importing Libraries:** Importing all necessary libraries in accordance with your problem statements is the initial step in any Python data pre-processing. The most frequently used, or basic, libraries are sklearn, which is one of the most powerful libraries utilised for this project, pandas for importing and exporting datasets, and numpy for doing mathematical operations.
- **Loading Datasets:** The datasets are loaded after the libraries have been imported. I've utilised comma-separated values (.csv) files here.
- **Handling Missing Values:** The mean technique is used to replace the dataset's values that are not present, which are displayed as NaN.
- **Handling Categorical Variable:** During this stage, we use the LabelEncoder Python module from to handle the categorical variables, use the Python Sklearn Pre-processing Library. Because handling missing values requires that data be maintained in numerical form, categorical values must be managed by converting the string into a numeric.

9.2 Data Vectorization and Feature Engineering

The application of feature engineering approaches usually comes after the collection and cleaning of the input data. Therefore, it is essential to repurpose these unprocessed data sources to create useful functionalities that describe a specific quality of the observations before using any machine learning technique. Usually, the cleaning stage involves dealing with duplicates, outliers, mistakes, and missing values. A portion of the distinctive characteristics are acquired as a result of the feature selection step's removal of unnecessary or redundant features. This can be carried out either before or after creating the machine learning model.

9.3 Model Development

To create an ML model, data must be divided into two sets, such as a "training set" and "testing set," with a ratio of 80:20 or 70:30; Depending on the type of input data and desired business consequence, a range of supervised (for labelled data) and unsupervised (for unlabelled data) algorithms are available for selection.

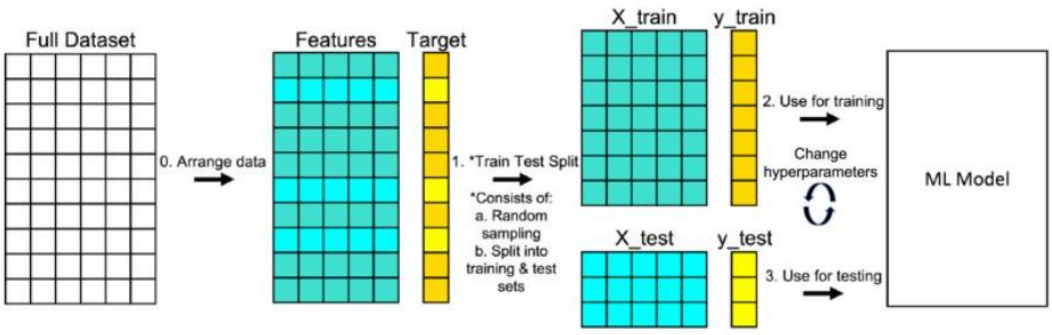


Fig 10: Train test split Image: Michael Galarnyk

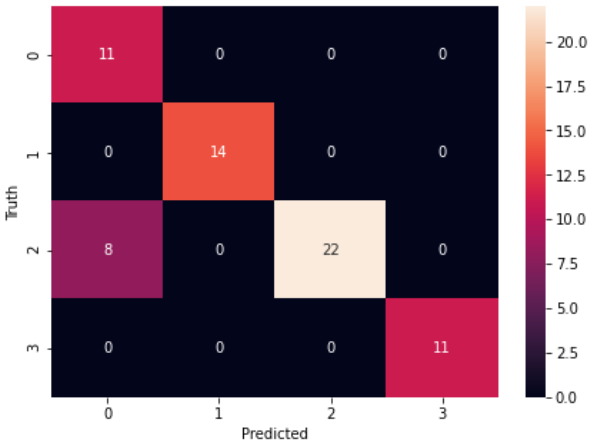
9.3.1 Model Evaluation

The following model evaluation metrics are used to assess how well various machine learning algorithms perform.

9.3.2 Confusion Matrix

An analytical technique used in machine learning for predicting is called the confusion matrix. A classification-based machine learning model is evaluated using the confusion matrix. The effectiveness of a classification model is evaluated using a N x N matrix termed a confusion matrix, where N is the total number of target classes. By visualising the confusion matrix and counting the number of accurate classifications, I was able to judge the model's accuracy.

The confusion matrix is a square matrix with the row showing the predicted value of the model and the column showing the actual values.



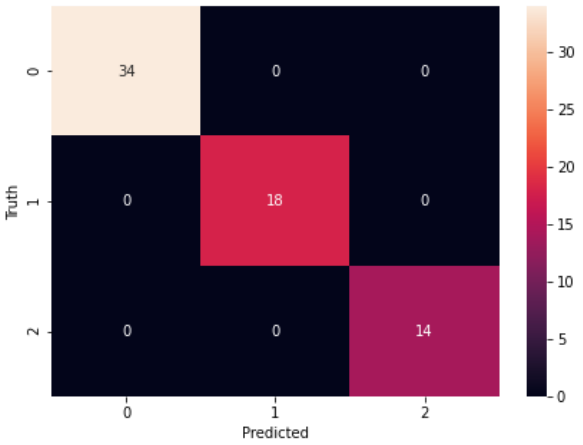


Fig 11: Confusion Matrix for Seizure Disease *Fig 12: Confusion Matrix for Fever Disease*

9.3.3 Accuracy Score

The number of accurate predictions your model made throughout the complete test dataset is known as accuracy. A useful fundamental statistic for assessing the success of the model is accuracy. Accuracy is no longer a good statistic for unbalanced datasets.

$$Accuracy = \frac{tp + tn}{tp + tn + fp + fn}$$

9.3.4 Precision, Recall, F1- Score and Classification report

Precision measures the proportion of accurate predictions made by the model to all successful forecasts. It can use it to determine how accurate your model is. Recall is the ratio of true positives to real positives, which can be determined by combining true positives and false negatives. Precision and recall are used in the F1-score formula's calculation. Precision and accuracy are balanced well by F1-score.

$$Precision = \frac{tp}{tp + fp}$$

$$Recall = \frac{tp}{tp + fn}$$

$$F1 - score = \left(\frac{2}{recall^{-1} + precision^{-1}}\right) = 2 * \frac{precision * recall}{precision + recall}$$

Accuracy, precision, f1-score, and recall are all combined into one report in the classification report.

9.4 Model Development and Training

9.4.1 Model Training

We assume a consistent train-test split ratio of 80-20 for comparing all the various models. This indicates that the model is trained using 80% of the dataset, with the remaining 20% being utilised for testing. All of the different models' train-test split ratios are fixed so that we may compare their accuracy. The model was trained on a total of 264 rows of data, and about 20% of those rows were used to test the model's effectiveness.

9.5 Machine Learning Models

Different models are developed using various machine learning methods that are utilised to address the classification issues covered in section 5 and 7. We go over the various evaluation metrics in the section that follows, which was collected by putting several machine learning models to the test on the test dataset.

9.5.1 Support Vector Machine

Using a linear SVC Classifier, the result was a multi-class support vector machine model. Afterward, the model is examined using our test data, and the results are displayed in Figure as precision, recall, f1-score, and accuracy scores.

	precision	recall	f1-score	support
0	0.58	1.00	0.73	11
1	1.00	1.00	1.00	14
2	1.00	0.73	0.85	30
3	1.00	1.00	1.00	11
accuracy			0.88	66
macro avg	0.89	0.93	0.89	66
weighted avg	0.93	0.88	0.89	66

Fig 13: Classification metrics for Seizure disease using SVM

	precision	recall	f1-score	support
0.0	1.00	1.00	1.00	34
1.0	1.00	1.00	1.00	18
2.0	1.00	1.00	1.00	14
accuracy			1.00	66
macro avg	1.00	1.00	1.00	66
weighted avg	1.00	1.00	1.00	66

Fig 14: Classification metrics for Fever disease using SVM

The model performs with an accuracy of 100% for fever disease and 89% for seizure disease on our test data while giving an accuracy of same for fever and 88% for seizure disease when evaluated on training data. For ten iterations, the cross validation mean accuracy is again same for fever and for seizure is 93%.

9.5.2 K- Nearest Neighbors

KNN currently is the most accurate, with validation accuracy of 89% and training accuracy of 85% for seizure disease and for fever is 100% for both. The individual f1-scores for all labels, as shown in figure, are all above 70%, which is the highest number to date. 89% is the cross-validation mean accuracy.

	precision	recall	f1-score	support
0	0.56	0.82	0.67	11
1	1.00	1.00	1.00	14
2	1.00	0.73	0.85	30
3	0.79	1.00	0.88	11
accuracy			0.85	66
macro avg	0.84	0.89	0.85	66
weighted avg	0.89	0.85	0.85	66

Fig 15: Classification metrics for seizure disease using KNN

	precision	recall	f1-score	support
0.0	1.00	1.00	1.00	34
1.0	1.00	1.00	1.00	18
2.0	1.00	1.00	1.00	14
accuracy			1.00	66
macro avg	1.00	1.00	1.00	66
weighted avg	1.00	1.00	1.00	66

Fig 16: Classification metrics for fever disease using KNN

9.5.3 Gaussian Naïve Bayes Classifier

We utilise Gaussian Naive Bayes, a subset of the naive bayes classifier, to simulate the distribution of features as we have many target variables. With several labels' f1-scores falling below 55% for seizure and 90% for fever seizure, it is seen that multinomial naive Bayes performs worse than SVM, as demonstrated in Figure

	precision	recall	f1-score	support
0	0.58	1.00	0.73	11
1	0.45	1.00	0.62	14
2	1.00	0.17	0.29	30
3	1.00	1.00	1.00	11
accuracy			0.62	66
macro avg	0.76	0.79	0.66	66
weighted avg	0.81	0.62	0.55	66

Fig 17: Classification metrics for seizure disease for GNB

	precision	recall	f1-score	support
0.0	1.00	1.00	1.00	34
1.0	0.75	1.00	0.86	18
2.0	1.00	0.57	0.73	14
accuracy			0.91	66
macro avg	0.92	0.86	0.86	66
weighted avg	0.93	0.91	0.90	66

Fig 18: Classification metrics for fever disease for GNB

9.5.4 Model Selection

The table below displays the various models' training and validation accuracy as well as their accuracy score. The most up-to-date models, such as SVM and KNN, perform equally well or more accurately than other machine learning models, such as the Gaussian Naive Bayes model, when we evaluate the accuracy of various models used to match the data. We can infer that the SVM and KNN models' accuracy for the fever disease is 100% because either we have a tiny dataset or the model is over-fitted.

The three selected models' training and validation accuracy are compared in Table, and it is clear that KNN performs the best.

Algorithms	Accuracy	Sensitivity	Precision
SVM	0.87	0.93	0.93
KNN	0.84	0.88	0.89
GNB	0.62	0.78	0.81

Fig 19: Model performance using different word embedding techniques for seizure disease

Algorithms	Accuracy	Sensitivity	Precision
SVM	1.0	1.0	1.0
KNN	1.0	1.0	1.0
GNB	0.90	0.85	0.93

Fig 20: Model performance using different word embedding techniques for fever disease

9.6 Results and Discussions

The distribution of accuracy scores across all departments for seizure and fever sickness is shown in Fig 19 and 20 for all the various models. Both the figures make it clear that, out of all the models utilised, Gaussian Naive Bayes has the lowest accuracy rating. In terms of accuracy, the SVM model for seizure disorder comes in first place with 87%, followed by KNN and GNB. In contrast, the accuracy of SVM and KNN, which is 100%, and GNB, which is 90%, for fever diseases are both different. This suggests that the model may be over-fitted or that there may not be enough data to obtain an accurate representation of the fever condition.

Every model and label seemed to be doing well. It is clear that the types of data being used make it more difficult for models to specify a line dividing one department from the others. In the upcoming section we compare the types of labels over age versus gender.

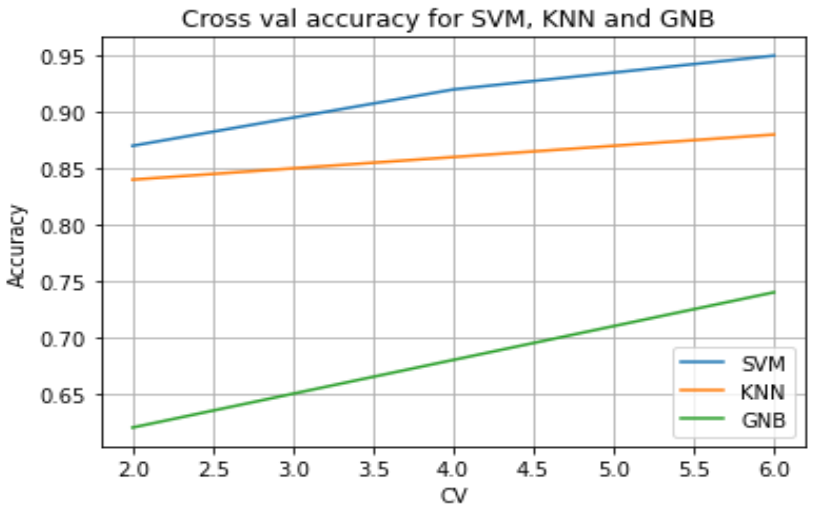


Fig 21: Comparison of accuracy score between SVM, KNN, GNB for seizure disease

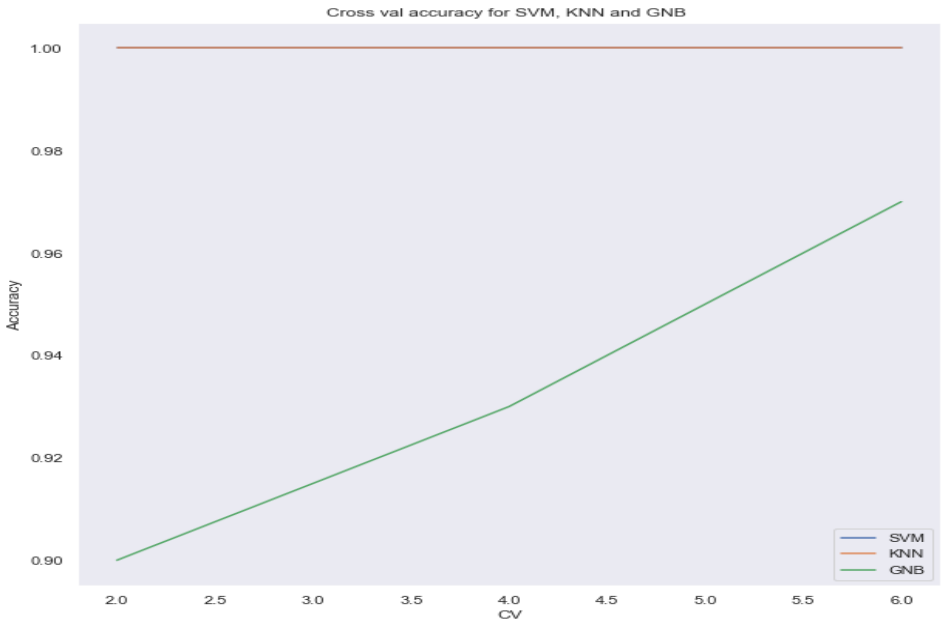


Fig 22: Comparison of accuracy score between SVM, KNN, GNB for fever disease

In the below graph, comparison is done between different types of labels that is department versus age over gender. In the first grapgh we can see that GP have also same level of patients while compared to A&E. According to the dataset, the analysis shows that average age of patients above 50 are needed more primary and emergency care for seizure disease.

When it compared to other grapgh for fever, we can say that males are most visited patients in A&E service department while compared to others that is GP and pharmacists.

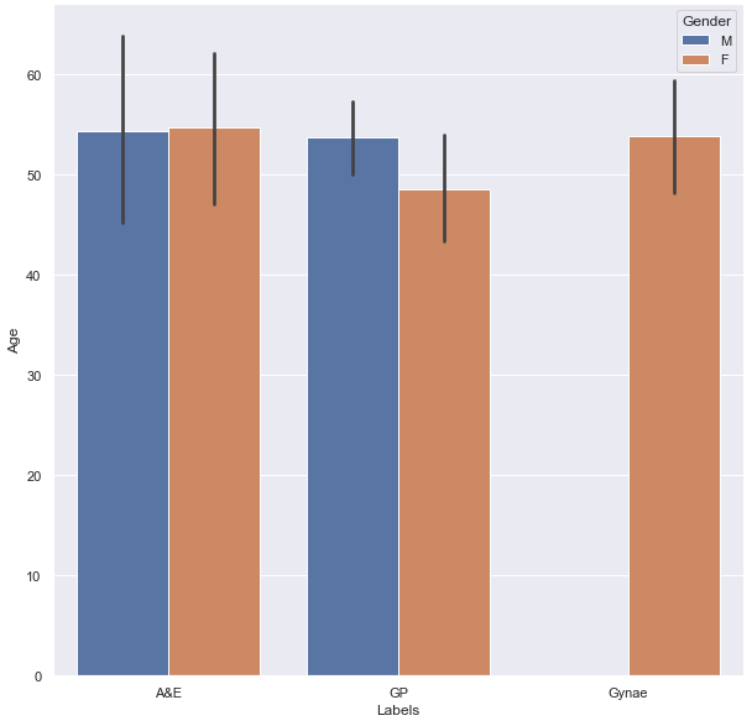


Fig 23: Type of Labels vs Age over the Gender for seizure disease

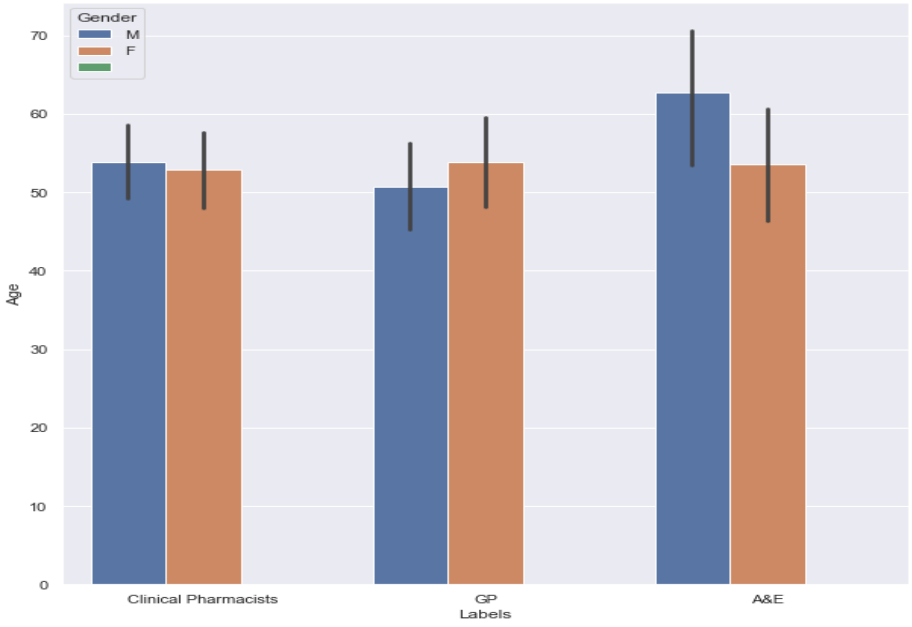


Fig 24: Type of Labels vs Age over the Gender for fever disease

Although some of the models used in the previously mentioned demonstrations showed an accuracy above 85%, the usage of categorical datasets has limited some of the text categorization models' potential. The tests conducted in this section indicate that the best model for the provided dataset is logistic regression. Of all the models, logistic regression requires the least amount of computing.

10. Conclusion

10.1 Summary

- The goal of this project is to aid the accident and emergency service department in making decisions and, ideally, to contribute to obtaining quicker triage times. The main objective of the research has been to improve the results by using different types of data on various machine learning and deep learning models to raise the prediction accuracy of the triage system. By 2021, Briggs
- In order to aid in text classification, the research used a variety of models that employ a variety of techniques to determine query similarity.
- I conclude that this is an interesting study with all these concepts such as machine learning algorithms, tuning data to fit model were unfamiliar parameters for me but throughout this journey I acquired these skills.
- With the help of AI, NLP & ML algorithms, I built an automated website for patient queries, which helps to reduce wait times for NHS.
- IBM Watson, an AI engine is used to derived questions and sends the request to UI, simultaneously ML models like SVM, KNN, GNB classifiers are trained to predict solution & helps UI to interpret results.
- Classification evaluation metrics like accuracy, precision, confusion matrix & sensitivity is used to measure the positive Reponses.
- While comparing the accuracy with different models, its assumed that SVM have the highest accuracy rate i.e. 87% as compared to KNN & GNB has the lowest rate 62% for seizure disease. The accuracy rate for seizure disease with SVM & KNN model is same that is 100%. This describes that model is good fit.
- The three selected models' training and validation accuracy are compared in the study, and it is clear that KNN performs the best.
- Further, analysis is done between labels vs age over gender, that all patients coming to A&E not exactly required A&E service, after rapid assessments its detected that patients can visit to GP or clinical pharmacist.

10.2 Additional Functionalities of the System

A user interface that has been integrated with the chosen model is produced for this automated system. A list of warning signs has been established to determine if the patient need emergency care or not. Calling 999 or going to an emergency room is advised for patients with life-threatening symptoms facility, according to the user interface's careful design. The user interface's landing page is displayed in Figure.

The user interface (UI) is designed to interact utilising the model file, which predicts which primary care network department the patient should be triaged to and sends the output to the user interface (UI). Every time a patient submits a request, another service that has been established sends an acknowledgement with medical advice based on patient diseases to the patient. In order to guarantee that the patient receives acknowledgement, we are sending this message.

The front end includes incorporated Google Calendar API, which retrieves the most recent events from the relevant doctor's calendar and aids in setting up an appointment for the earliest time window. The appointment time and date are also sent to the patient through email.

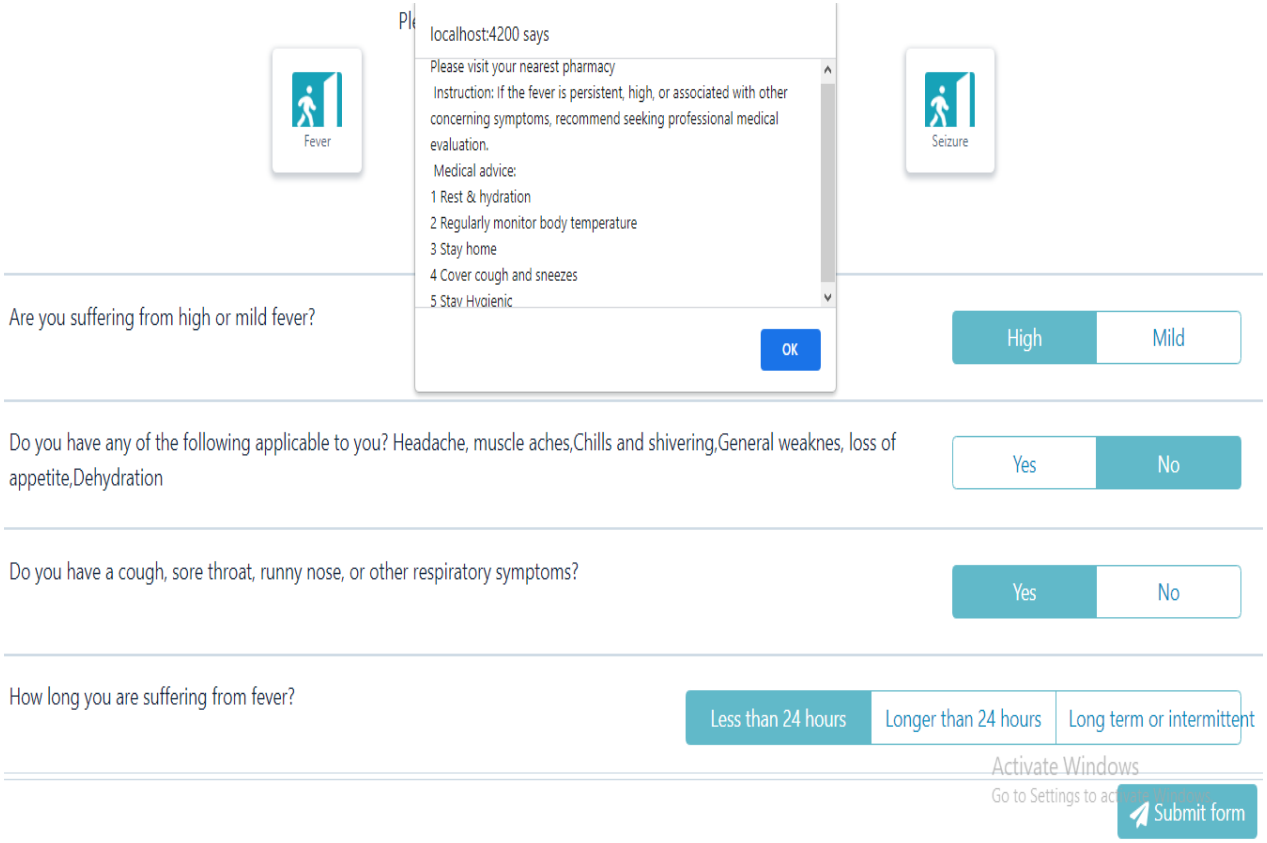


Fig 25: UI page (form)

10.3 Learning

This study not only enriched my skill set but also significantly contributed to the project's success. I have emerged from this experience with new skills and confidence, ready to tackle future challenges and contribute to the ever-evolving landscape of artificial intelligence.

11. Challenges in Project

1. I associated challenge in finding dataset because the data requirement for this project was confidential and had GDPR compliance. It was a tedious task to generate synthetic data using different resources & websites and it took me weeks to generate the proper dataset.
2. I was required to develop skills which are outside of data science domain like building a User Interface as per project requirements, integrating and deploying the system which I was not aware about before.

12. Future scope

Integrating NHS API

As in future if we get NHS API we can integrate into our system will enable seamless connectivity with GP & A&E, ensuring that the model remains operational.

Image Recognition

we can introduce advanced image recognition technology to enhance disease detection capabilities. This will help the patient to detect disease with the online system like for normal injury, rashes, infective and simultaneously it will help to reduce A&E wait times.

Nearest Point Service

Integrating application with available services (medicine) so that system can suggest user nearest point, with this patient can able to identify the medicines which he needs is available in his particular radius off licence store or pharmacists.

Self-Medical Care

The demonstration can include a component that provides information to users so they can get self-help for ailments that don't require medical attention.

13. References

1.NHS (2013). *Guide to the Healthcare System in England Including the Statement of NHS Accountability*. [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/194002/9421-2900878-TSO-NHS_Guide_to_Healthcare_WEB.PDF.

2.www.w3schools.com. (n.d.). *AngularJS Tutorial*. [online] Available at: https://www.w3schools.com/angular/default.asp.

3.IBM Watson Assistant for Health Benefits Drive fast, dynamic and personalized interactions with members, at scale. (n.d.). Available at: https://www.ibm.com/downloads/cas/NQ4DL4MQ [Accessed 28 Sep. 2023].

4.The King's Fund. (n.d.). *What's going on with A&E waiting times?* [online] Available at: https://www.kingsfund.org.uk/projects/urgent-emergency-care/urgent-and-emergency-care-mythbusters#:~:text=Waiting%20times%20for%20A%26E%20care [Accessed 28 Sep. 2023].

5.nhsproviders.org. (n.d.). *Is automation the future of the NHS? - NHS Providers*. [online] Available at: https://nhsproviders.org/news-blogs/blogs/is-automation-the-future-of-the-nhs [Accessed 28 Sep. 2023].

6.Nuffield Trust (2018). *A&E waiting times*. [online] The Nuffield Trust. Available at: https://www.nuffieldtrust.org.uk/resource/a-e-waiting-times.

7.May 2022 RPA in the NHS Guidance for designing, delivering and sustaining RPA within the NHS. (n.d.). Available at: https://transform.england.nhs.uk/media/documents/RPA-Guidance-May-22.pdf.

8.Javid, S. (2022). *Health and Social Care Secretary speech on Health Reform*. [online] GOV.UK. Available at: https://www.gov.uk/government/speeches/health-and-social-care-secretary-speech-on-health-reform.

9.Alhaidari, F., Almuhaideb, A., Alsunaidi, S., Ibrahim, N., Aslam, N., Khan, I.U., Shaikh, F., Alshahrani, M., Alharthi, H., Alsenbel, Y. and Alalharith, D. (2021). E-Triage Systems for COVID-19 Outbreak: Review and Recommendations. *Sensors*, 21(8), p.2845. doi:https://doi.org/10.3390/s21082845.

10.www.lexalytics.com. (2020). *Machine Learning (ML) for Natural Language Processing (NLP) - Lexalytics*. [online] Available at: https://www.lexalytics.com/blog/machine-learning-natural-language-processing/.

11.blog.hubspot.com. (n.d.). *What Is AngularJS? (in 100 Words or Less)*. [online] Available at: https://blog.hubspot.com/website/angular-js.

12.www.javatpoint.com. (n.d.). *AngularJS MVC Architecture - javatpoint*. [online] Available at: https://www.javatpoint.com/angularjs-mvc-architecture.

13.Bogatinovski, J., Todorovski, L., Džeroski, S. and Kocev, D. (2021). *Comprehensive Comparative Study of Multi-Label Classification Methods*. [online] arXiv.org. doi:https://doi.org/10.48550/arXiv.2102.07113.

14.Pilbery, R., Smith, M., Green, J., Chalk, D. and O'Keeffe, C.A. (2023). Modelling NHS England 111 demand for primary care services: a discrete event simulation. *BMJ Open*, [online] 13(9), p.e076203. doi:https://doi.org/10.1136/bmjopen-2023-076203.

15.Zhou, L., Zheng, X., Yang, D., Wang, Y., Bai, X. and Ye, X. (2021). Application of multi-label classification models for the diagnosis of diabetic complications. *BMC Medical Informatics and Decision Making*, 21(1). doi:https://doi.org/10.1186/s12911-021-01525-7.

16.Busuttil, S. (n.d.). *Support Vector Machines*. [online] Available at: https://core.ac.uk/download/pdf/84895067.pdf.

17.JavaTPoint (n.d.). Support Vector Machine (SVM) Algorithm - Javatpoint. [online] www.javatpoint.com. Available at: https://www.javatpoint.com/machine-learning-support-vector-machine-algorithm.

18.Karimi, Z. (2021). *(PDF) Confusion Matrix*. [online] ResearchGate. Available at: https://www.researchgate.net/publication/355096788_Confusion_Matrix.

19.NHS Transformation Directorate. (n.d.). *Using AI to improve back office efficiency in the NHS*. [online] Available at: https://transform.england.nhs.uk/ai-lab/explore-all-resources/understand-ai/using-ai-to-improve-back-office-efficiency-in-the-nhs/.

20.OpenGenus IQ: Computing Expertise & Legacy. (2020). *Gaussian Naive Bayes*. [online] Available at: https://iq.opengenus.org/gaussian-naive-bayes [Accessed 28 Sep. 2023].

21.Suyal, M. and Goyal, P. (2022). A Review on Analysis of K-Nearest Neighbor Classification Machine Learning Algorithms based on Supervised Learning. *International Journal of Engineering Trends and Technology*, 70(7), pp.43–48. doi:https://doi.org/10.14445/22315381/ijett-v70i7p205.

14. Appendix

Two notebooks are attached to find the code, as the code is exceeding length of words.

Fever_Dissertation.ipynb

Seizure_Fit_Dissertation (1).ipynb

Appendix 1: Seizure Disease

In [ ]:

```
print("connected")
import json
import numpy as np
from sklearn.preprocessing import MinMaxScaler
import pandas as pd
REQUEST = json.dumps({
'path' : {},
'args' : {}
})
request = json.loads(REQUEST)
name = request['path'].get('name')


print('connected')
#Importing the dataset
s = open('Seizure_or_fit_final.csv')
SeizureFrame = pd.read_csv(s)
#Data Preprocessing
print(SeizureFrame.head(5))

# In[7]:

SeizureFrame.shape
SeizureFrame.describe()
from sklearn.preprocessing import LabelEncoder
from sklearn import preprocessing
# label_encoder object knows
# how to understand word labels.
label_encoder = preprocessing.LabelEncoder()

# Encode labels in column 'species'.
SeizureFrame['Labels']= label_encoder.fit_transform(SeizureFrame['Labels'])

SeizureFrame['Labels'].unique()
```

```
# In[8]:
#Taking care of Missing values and dropping null values
SeizureFrame = SeizureFrame.dropna()
SeizureFrame
print(SeizureFrame.head(5))

# In[9]:

Labels = SeizureFrame['Labels']

# In[10]:

Labels

# In[11]:

#Dropping the label column
SeizureFrame = SeizureFrame.drop('Labels',axis=1)

# In[12]:

# training a SVM classifier with linear kernel
#Splitting of the data set in Training and Test sets
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(SeizureFrame, Labels, random_state = 0)

# In[13]:

from sklearn.svm import SVC
svm_model_linear = SVC(kernel = 'linear', C = 7).fit(X_train, y_train)
svm_predictions = svm_model_linear.predict(X_tes
```

```
accuracy = svm_model_linear.score(X_test, y_test)

# creating a confusion matrix
cm = confusion_matrix(y_test, svm_predictions)
In [15]:

# In[15]:

accuracy

# In[16]:

#confusion matrix Array
cm

# In[17]:

#plotting a graph for Confusion matrix
%matplotlib inline
import matplotlib.pyplot as plt
import seaborn as sn
plt.figure(figsize=(7,5))
sn.heatmap(cm, annot=True)
plt.xlabel('Predicted')
plt.ylabel('Truth')

# In[18]:

from sklearn.metrics import classification_report
```

```
from sklearn.metrics import fbeta_score
fbeta_score(y_test, svm_predictions, average='macro', beta=10)

# In[20]:

# training a KNN classifier
from sklearn.neighbors import KNeighborsClassifier
knn = KNeighborsClassifier(n_neighbors = 4).fit(X_train, y_train)

# accuracy on X_test
accuracy = knn.score(X_test, y_test)
print(accuracy)

# creating a confusion matrix
knn_predictions = knn.predict(X_test)
cm = confusion_matrix(y_test, knn_predictions)

# In[21]:

from sklearn.metrics import classification_report

print(classification_report(y_test,knn_predictions))

# In[22]:

from sklearn.metrics import fbeta_score
fbeta_score(y_test, knn_predictions, average='macro', beta=10)

# In[23]:

# training a GaussianNB classifier
from sklearn.naive_bayes import GaussianNB
gnb = GaussianNB().fit(X_train, y_train)
gnb_predictions = gnb.predict(X_test)
```

```
from sklearn.metrics import fbeta_score
fbeta_score(y_test, gnb_predictions, average='macro', beta=10)

# In[26]:
from IPython.display import HTML, display
import tabulate
table = [["Algorithm Name","Accuracy","Senestivity","Precision"],
    ["SVM",0.87,0.93,0.93],
         ["KNN",0.84,0.88,0.86],
         ["GNB",0.62,0.78,0.81]]
display(HTML(tabulate.tabulate(table, tablefmt='html')))

# In[27]:
import matplotlib.pyplot as plt
# line 1 points
x1 = [2,4,6]
y1 = [0.87,0.92,0.95]
# plotting the line 1 points
plt.plot(x1, y1, label = "SVM")
#plt.plot(x1, y1, color='green', linestyle='dashed', linewidth = 3,
      #   marker='o', markerfacecolor='blue', markersize=12, label = "SVM")
# line 2 points
x2 = [2,4,6]
y2 = [0.84,0.86,0.88]
# plotting the line 2 points
plt.plot(x2, y2, label = "KNN")
# line 2 points
x3 = [2,4,6]
y3 = [0.62,0.68,0.74]
# plotting the line 2 points
plt.plot(x3, y3, label = "GNB")
plt.xlabel('CV')
# Set the y axis label of the current axis.
plt.ylabel('Accuracy')
# Set a title of the current axes.
plt.title('Cross val accuracy for SVM, KNN and GNB ')
```

```
# In[28]:
X_test

# In[29]:
gnb_predictions

# In[30]:
data = [[1,0,1,5,5,5,5,5,5,0]]
df = pd.DataFrame(data, columns=['Q1','Q2','Q3','Q4','Q5','Q6','Q7','Q8','Q9','Gender'])
gnb_predictions = gnb.predict(df)
gnb_predictions

# In[31]:
#Data Analysis using Bar Chart
seizure = pd.read_csv('Seizure_or_fit.csv')
seizure.head()

# In[32]:
import seaborn as sns
import matplotlib.pyplot as plt
sns.countplot(x='Labels',hue='Gender',data=seizure)
sns.set(rc={'figure.figsize':(10,10)})
plt.title("Type of Labels Count over the Gender")

# In[33]:
sns.barplot(x = 'Labels',
            y = 'Age',
            hue = 'Gender',
            data = seizure)

# Show the plot
plt.show()
```

Appendix 2: Code of UI: Angular JS

```
import { Component, OnInit, ElementRef, HostListener, ViewChild, TemplateRef }
from '@angular/core';
import { NgbModal } from '@ng-bootstrap/ng-bootstrap';

import { Subject, Observable, forkJoin, of, timer } from 'rxjs';
import { switchMap, catchError } from 'rxjs/operators';
@Component({
  selector: 'app-dynamic-forms',
  templateUrl: './dynamic-forms.component.html',
  styleUrls: ['./dynamic-forms.component.css']
})
export class DynamicFormsComponent implements OnInit {
    @ViewChild('casePopContent', { static: true }) modalContent:
TemplateRef<any>;
  constructor( ) { }
  formElements = [];
  modalMessage = 'Your session is about to expire, please complete the form or
click reset to start again';
  modalTitle = 'User inactivity';
  serviceLines = [
    {
        "label": "Fever",
        "value": "8b52478f-e965-478c-bd60-48558a136b16",
        "onhov": "assets/brand/JobIcons/BranchEquipment-01h.png",
        "nohov": "assets/brand/JobIcons/BranchEquipment-01.png",
        "imgsrc": "assets/brand/JobIcons/BranchEquipment-01.png"
    },
    {
        "label": "Seizure",
        "value": "3f225b3d-3c26-4ab4-94bf-7e4f09182198",
        "onhov": "assets/brand/JobIcons/BuildingRepairs-01h.png",
        "nohov": "assets/brand/JobIcons/BuildingRepairs-01.png",
        "imgsrc": "assets/brand/JobIcons/BuildingRepairs-01.png"
    },
    // {
    //     "label": "Sudden Rapid Swelling",
    //     "value": "3df99cca-0801-4edc-98b9-ca074ed5b717",
    //     "onhov": "assets/brand/JobIcons/Catering-01h.png",
    //     "nohov": "assets/brand/JobIcons/Catering-01.png",
    //     "imgsrc": "assets/brand/JobIcons/Catering-01.png"
    // },
    // {
    //     "label": "Difficulty in breathing",
    //     "value": "85448374-6c9b-4839-b2a3-e87b77d6b7f8",
    //     "onhov": "assets/brand/JobIcons/Cleaning-01h.png",
    //     "nohov": "assets/brand/JobIcons/Cleaning-01.png",
    //     "imgsrc": "assets/brand/JobIcons/Cleaning-01.png"
```

```
    // },
]
requestInProgress = false;
// Flag is used to show loading by default and for the case if Request is
taking more than a specified time(2 Sec).
showLoading = false;
hideOnReset = true;
loadingMessage = 'Processing your request, please wait…';
selectedServiceLine: any;
  ngOnInit(): void {
  }
  activateServiceLine(serviceLine: any): void {
    console.log(serviceLine);

    var resp = this.getAIresponse(serviceLine,null);
    this.formatGenericResponse(resp);
  }

  private formatGenericResponse(generic): void {

    let formElement = {
      labels: [],
      controls: []
    };

    let hideCreateCaseFrom = true;

    generic.forEach((item) => {


      if (item.type == 'text') {

        formElement.labels.push(item);

      } else {

        item.hideCreateCaseFrom = hideCreateCaseFrom;
        formElement.controls.push(item);

      }

    });

    this.formElements.push(formElement);


  }

  formatServiceLineText(text: string): string {
```

```
    if(text == 'cleaning'){
      text = 'Cleaning / Medical';
    }



    return (text.charAt(0).toUpperCase() + text.slice(1)).split(/(?=[A-
Z])/).join(' ');

  }

  getAIresponse(text:any,valu:any):any{

// ONLY FOR INITIAL LOADING
    if (text.label){

         return[
        {
          "type": "input",
          "disease":text.label,
          "Q":1

        },
        {
          "type": "text",
          "text": "Please describe the medical problem. Attach
photo(Optional)"
        }
      ]
    }
    if (text.disease =="Fever" && text.Q == 1 ){

        return[
            {
                "type": "buttons",
                "buttons": [
                    {
                        "label": "High",
                        "value": "node_6_1627644972099"
                    },
                    {
                        "label": "Mild",
                        "value": "node_1_1544531776516"
                    }
                ],
                "hideCreateCaseFrom": true,
                "disease":text.disease,
                "Q":2
```

```
            },
            {
                "type": "text",
                "text": "Are you suffering from high or mild fever? "
            }
        ]
    }
    else if (text.disease =="Fever" && text.Q == 2 ){

     return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":3
        },
        {
            "type": "text",
            "text": "Do you have any of the following applicable to you?
Headache, muscle aches,Chills and shivering,General weaknes, loss of
appetite,Dehydration"

        }
    ]
}
    else if (text.disease =="Fever" && text.Q == 3 ){

        return[
            {
                "type": "buttons",
                "buttons": [
                    {
                        "label": "Yes",
                        "value": "node_6_1627644972099"
                    },
                    {
                        "label": "No",
                        "value": "node_1_1544531776516"
```

```
                    }
                ],
                "hideCreateCaseFrom": true,
                "disease":text.disease,
                "Q":4
            },
            {
                "type": "text",
                "text": "Do you have a cough, sore throat, runny nose, or
other respiratory symptoms?"

            }
        ]
}
else if (text.disease =="Fever" && text.Q == 4 ){

    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Less than 24 hours",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "Longer than 24 hours",
                    "value": "node_1_1544531776516"
                },
                {
                    "label": "Long term or intermittent",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":5
        },
        {
            "type": "text",
            "text": "How long you are suffering from fever? "

        }
    ]
}
else if (text.disease =="Fever" && text.Q == 5 ){

    if(valu.label =="Long term or intermittent" )
{
```

```
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":6
        },
        {
            "type": "text",
            "text": "Is there a recent history of travel to endemic areas? "

        }
    ]
}
else{
    alert("Please visit your nearest pharmacy\n Instruction: If the fever is
persistent, high, or associated with other concerning symptoms, recommend
seeking professional medical evaluation.\n Medical advice:\n1 Rest &
hydration\n2 Regularly monitor body temperature\n3 Stay home\n4 Cover cough
and sneezes\n5 Stay Hygienic");
}

}
else if (text.disease =="Fever" && text.Q == 6 ){

    if(valu.label =="No" )
{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
```

```
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":7
        },
        {
            "type": "text",
            "text": "Are you experiencing difficulty in breathing, confusion,
chest pain? "

        }
    ]
}
else{
    alert("Visit a Pharmacist");
}

}
else if (text.disease =="Fever" && text.Q == 7 ){

    if(valu.label =="No" ){
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":8
        },
        {
            "type": "text",
            "text": "Have you been in close contact with anyone who is sick or
has a fever?"

        }
    ]
```

```
}
else{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":9
        },
        {
            "type": "text",
            "text": "Do you have a history of chronic medical conditions, such
as diabetes, heart disease, or immune disorders? "

        }
    ]
}
}
else if (text.disease =="Fever" && text.Q == 8 ){

    if(valu.label =="No" )
{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
```

```
            "Q":9
        },
        {
            "type": "text",
            "text": "Do you have a history of chronic medical conditions, such
as diabetes, heart disease, or immune disorders? "

        }
    ]
}
else{
    alert("Visit your registered GP");
}

}

else if (text.disease =="Fever" && text.Q == 9 ){

    if(valu.label =="No" )
{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":10
        },
        {
            "type": "text",
            "text": "Have you experienced any recent injuries, surgeries, or
other events that might be related to the fever?"

        }
    ]
}
else{
    alert("Visit A&E (Accident & Emergency) As soon as possible");
```

```
}

}

else if (text.disease =="Fever" && text.Q == 10 ){

    if(valu.label =="No" )
{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":11
        },
        {
            "type": "text",
            "text": "Do you have a history of allergies to medications or
known medical conditions? "

        }
    ]
}
else{
    alert("Your appointment is scheduled with your registered
GP.\nInstruction: If the fever is persistent, high, or associated with other
concerning symptoms, recommend seeking professional medical
evaluation.\nMedical advice:\n1. Rest & hydration\n2. Regularly monitor body
temperature\n3. Stay home\n4. Cover cough and sneezes\n5. Stay Hygienic ");
}

}
else if (text.disease =="Fever" && text.Q == 11 ){

    if(valu.label =="No" )
{
```

```
    alert("Your appointment is scheduled with your registered
GP.\nInstruction: If the fever is persistent, high, or associated with other
concerning symptoms, recommend seeking professional medical
evaluation.\nMedical advice:\n1. Rest & hydration\n2. Regularly monitor body
temperature\n3. Stay home\n4. Cover cough and sneezes\n5. Stay Hygienic ");
}
else{
    alert("Your appointment is scheduled for future diagnosis.\nInstruction:
If the fever is persistent, high, or associated with other concerning
symptoms, recommend seeking immediate professional medical
evaluation.\nMedical advice:\n1. Rest & hydration\n2. Regularly monitor body
temperature\n3. Stay home\n4. Cover cough and sneezes\n5. Stay Hygienic ");
}

}
if (text.disease =="Seizure" && text.Q == 1 ){

    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":2
        },
        {
            "type": "text",
            "text": "Is this your first seizure? "
        }
    ]
}
if (text.disease =="Seizure" && text.Q == 2 ){

    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
```

```
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":3
        },
        {
            "type": "text",
            "text": "Is the seizure lasting longer than 5 minutes?"
        }
    ]
}
if (text.disease =="Seizure" && text.Q == 3 ){

    return[
        {
            "type": "input",

            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":4
        },
        {
            "type": "text",
            "text": "What did you observe during seizure, describe movements
or behaviours?"
        }
    ]
}
if (text.disease =="Seizure" && text.Q == 4 ){

    return[
        {
            "type": "input",

            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":5
        },
        {
            "type": "text",
            "text": "When did the seizure start?"
        }
```

```
    ]
}
else if (text.disease =="Seizure" && text.Q == 5 ){

    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Pregnant",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "Injured",
                    "value": "node_1_1544531776516"
                },
                {
                    "label": "Signs of Illness",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":6
        },
        {
            "type": "text",
            "text": "Choose any of applicable? "

        }
    ]
}
else if (text.disease =="Seizure" && text.Q == 6 ){

    if(valu.label =="Signs of Illness" )
{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
```

```
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":7
        },
        {
            "type": "text",
            "text": "Did you lose consciousness during seizure? "

        }
    ]
}
else if(valu.label=="Pregnant"){
    alert("Please visit Gynac");
}
else{
    alert("Visit Physio");
}
}
if (text.disease =="Seizure" && text.Q == 7 ){

    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":8
        },
        {
            "type": "text",
            "text": "Is there any difficulty breathing or abnormal breathing
sounds?"
        }
    ]
}

else if (text.disease =="Seizure" && text.Q == 8 ){
```

```
    if(valu.label =="No" )
{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":9
        },
        {
            "type": "text",
            "text": " Have you been injured during the seizure? Are there any
visible injuries or signs of trauma?        "

        }
    ]
}
else{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":10
        }   ,
```

```
        {
            "type": "text",
            "text": "Are you currently on any medications or treatments for
seizures or other medical conditions? "

        }
    ]
}

}

else if (text.disease =="Seizure" && text.Q == 9 ){

    if(valu.label =="No" )
{
    return[
            {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":10
        },
        {
            "type": "text",
            "text": " Are you currently on any medications or treatments for
seizures or other medical conditions?            "

        }
    ]
}
else{
alert("Visit GP");
}

}
else if (text.disease =="Seizure" && text.Q == 10 ){
```

```
    if(valu.label =="No" )
{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }

            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":11
        },
        {
            "type": "text",
            "text": "Do you have a history of allergies to medications or
known medical conditions? "

        }
    ]
}
else{
    alert("Visit registered GP");
}

}
else if (text.disease =="Seizure" && text.Q == 11 ){

    if(valu.label =="No" )
{
    return[
            {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
```

```
                }

              ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":12
        },
        {
            "type": "text",
            "text": " Are you experiencing a prolonged or unusual seizure? "

        }
    ]
}
else{
alert("Visit A&E");
}

}
else if (text.disease =="Seizure" && text.Q == 12 ){

        if(valu.label =="No" )
    {
        alert("Visit registered GP");
    }
    else{
        alert("Visit A&E as soon as possible");
    }

}
if (text.disease =="Difficulty in breathing" && text.Q == 1 ){

    return[
        {
            "type": "input",

            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":2
        },
        {
            "type": "text",
            "text": "When did the difficulty in breathing started? "
        }
    ]
}
if (text.disease =="Difficulty in breathing" && text.Q == 2 ){
```

```
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":5
        },
        {
            "type": "text",
            "text": "Are you consious but havig severe difficulty in breathing
?"
        }
    ]
}
else if (text.disease =="Difficulty in breathing" && text.Q == 3 ){

    if(valu.label =="No" ){
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":5
        },
        {
            "type": "text",
            "text": "Can you point where you are feeling the most discomfort
chest, throat, abdomen, nose?"
```

```
        }
    ]
}
else{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":4
        },
        {
            "type": "text",
            "text": "Is there a known history of allergies (eg. Anaphylaxis)?
"

        }
    ]
}
}
else if (text.disease =="Difficulty in breathing" && text.Q == 4 ){

    if(valu.label =="No" )
{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
```

```
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":5
        },
        {
            "type": "text",
            "text": "Can you point where you are feeling the most discomfort
chest, throat, abdomen, nose? "

        }
    ]
}
else{
    alert("Visit Cardiologist");
}

}
else if (text.disease =="Difficulty in breathing" && text.Q == 5 ){

    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":6
        },
        {
            "type": "text",
            "text": "Are you experiencing bluish lips or face, rapid
breathing, anxiety or panic, sweating, shortness of breath, shallow breathing,
unable to complete sentences due to breathlessness?"

        }
    ]
}
else if (text.disease =="Difficulty in breathing" && text.Q == 6 ){
```

```
    if(valu.label =="No" ){
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":7
        },
        {
            "type": "text",
            "text": "Do you had a sudden onset of breathing difficulty? "

        }
    ]
}
else{
    alert("Visit Cardiologist");
}

}
else if (text.disease =="Difficulty in breathing" && text.Q == 7 ){

    if(valu.label =="No" ){
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
```

```
            "Q":10
        },
        {
            "type": "text",
            "text": "Have you had any recent trauma or injury to the chest or
throat?"

        }
    ]
}
else{
    return[
        {
            "type": "buttons",
            "buttons": [
                {
                    "label": "Yes",
                    "value": "node_6_1627644972099"
                },
                {
                    "label": "No",
                    "value": "node_1_1544531776516"
                }
            ],
            "hideCreateCaseFrom": true,
            "disease":text.disease,
            "Q":8
        },
        {
            "type": "text",
            "text": "Have you ever been diagnosed with a condition that
affects your airway, such as asthma, chronic obstructive pulmonary disease
(COPD)? "

        }
    ]
}
}
//     if (text.label == "Seizure"){

//         return[
//        {
//          "type": "input",
//          "disease":"Seizure",

//        },
//        {
//          "type": "text",
```

```
//          "text": "Please describe the medical problem. Attach
photo(Optional)"
//        }
//      ]
//    }

    // return[
    //     {
    //       "type": "input",

    //     },
    //     {
    //       "type": "text",
    //       "text": "Please describe the medical problem. Attach
photo(Optional)"
    //     }
    //   ]
  }

  sendControlSelection(control,valu): void {

   var resp = this.getAIresponse(control,valu);
   this.formatGenericResponse(resp);
    // clearTimeout(this.userActivity);
    // this.setTimeout();

    // if (!control.value) {
    //   delete control.selected;
    //   return;
    // }

    // this.toggleInProgress();
    // this.toggleLoading();

    // this.chatAIConnect.postEnquiry(control.value, null,
this.formCreateCaseContext.serverAttachments).subscribe(
    //   (response: any) => {

    //     this.transactionId = response.transactionId;

    //     if (response.nluAttributes.caseDetails) {
    //       this.modalTitle = 'Case details';
    //       this.modalMessage = response.message.generic[0].text;
    //       window.parent.postMessage('caseCreated', '*');
    //       this.openLg(true);
    //     } else {
    //       this.formatGenericResponse(response.message.generic);
    //     }
```

```
    //     // this.showAttachments = response.nluAttributes.showAttachments;
    //     if (response.nluAttributes.showAttachments) {
    //       this.formElements[this.formElements.length - 1].showAttachments =
true;
    //     }

    //     this.toggleInProgress();
    //     this.toggleLoading();

    //   }, (error) => {

    //     // keep the input enabled so user can amend entry
    //     delete control.selected;

    //     if (error.errorDetails.includes('Session is expired')) {
    //       this.reset();
    //     }

    //     this.alerts.push({ text: `An Error occurred - ${error.errorDetails
|| error.message || JSON.stringify(error)}` });


    //     this.toggleInProgress();
    //     this.toggleLoading();
    //   });

  }


}
```

15. LinkedIn Submission

15.1 Post 1

I'm delighted to share that I have been working on dissertation for my Masters in Data Analytics for Business Intelligence with a year in Industry at University of Leicester. The main aim of the project is how could AI is used to improve A&E wait times? Our stakeholder work for A&E (Accident & Emergency) patients in acute medical care settings in NHS. I am interested to developed an automated system in which user will be asked to fill AI generated form having set of questions like a rapid assessment based on patient's diseases and redirect patient to appropriate service offering under the control of various department GP, Cardio, Physio, Gynae, A&E and clinical pharmacists. Additionally, it also provides simple medical assistance to patients.

The aim is to eliminate the time-consuming manual referral process while optimizing the utilization of existing resources. This project is an attempt to use AI to automate the triage process to relieve the A&E of this burden. My strategy involves building a user-friendly front end that allows users to input their health concerns. The system will then prompt them with relevant questions to gather information. This data will undergo analysis to accurately identify the user's medical condition and direct them to the appropriate healthcare professional. To achieve this, we leverage IBM Watson, a robust platform incorporating deep learning, machine learning, and natural language processing (NLP) models to comprehend queries, locate the most suitable answers, and execute the user's intended actions through conversational AI.

I'd like to seize this moment to express my gratitude to our industry mentor, Daniel English, for their unwavering support and encouragement over the past ten weeks. I'm also deeply thankful to our academic guide, Evgeny Mirkes, and our program director, Dr. Andrew Morozov, who have been valuable throughout every phase of our project. Lastly, I want to extend my appreciation to my teammates Garima Shrestha, Suresh Kunchapu, Amaan Patel, Fabiha Chowdhary for this wonderful journey.

#dataanalytics #universityofleicester #businessanalytics #ibmwatson #machinelearning #naturallanguageprocessing

15.2 Post 2

I'm thrilled to provide an update about my earlier post regarding my master's thesis, titled "Triage NHS patients with AI," in collaboration with the University of Leicester. This post serves as an overview of the methodology employed to build the AI generated automated system(form) having set of questions like a rapid assessment based on patient's diseases and redirect patient to appropriate department.

Data Collection: Real–time data is unavailable, Synthetic data is created in the form of questionnaire generated using different websites like WebMD and NHS to redirect patient to particular queue based on their symptoms, medical history for these two Diseases-Fever, Seizure(fit). Subsequently, the collected data undergoes a thorough cleaning process to eliminate any null values.
Feature Engineering: The raw data is transforms into features that used to create predictive model.
Model Development: Multilabel classification is used by using algorithms SVM, KNN and Gaussian Naïve Bayes to derive test & built to check which model fitting the best criteria.

Upon analysis, it was observed that SVM performs the best on test data, with an accuracy of around 87% for seizure disease, followed by KNN & GNB. For fever disease, SVM & KNN have 100% accuracy. Although SVM & KNN has higher accuracy, it slightly over fits the data.

IBM Watson: IBM Watson is used in this project to derived questions based on user(patient) input as it built on deep learning, Machine learning & natural language Processing models to elevate user experience. It employs NLP in various ways to understand & work with human language. IBM Watson can analyse text data to determine sentiment, emotion & tone. The four major algorithms used in this projects are Intent Detection, Entity Detection, Irrelevance Detection, Auto-correction. IBM Watson has made significant contributions to the healthcare industry by leveraging artificial intelligence (AI) and data analytics to enhance patient care, improve diagnoses, and streamline administrative processes.

Stay tuned for my final phase of the project. I will update it shortly.

#dataanalytics #ibmwatson #machinelearningalgorithms #naturallanguageprocessing #deeplearning #python #datascience

15.3 Post 3

📊 **Exciting Project Results: Triage NHS patients with AI** 📈

I am happy to share the final results o my recent academic project, "Triage NHS patients with AI". 🌟 The User interface for the automatic triage system has been built on AngularJS. Patients answer a series of questions that help the model in triaging patients to the appropriate department.

Additional features of the system:
1. The user interface is connected to a database. Any new entry into the automated system(form) gets saved along with the details of triage.
2. The system schedules an appointment with the concerned physician at the latest

available time slot.
3. After the appointment is scheduled, the patient is informed of the details of the booking via email.

Possible future enhancements:
1. Integrating the NHS API into our system will enable seamless connectivity with GP & A&E, ensuring that the model remains operational.
2. Introducing advanced image recognition technology to enhance disease detection capabilities.
3. Integrating application with available services (like medicines) so that system can suggest user nearest point.
4. The data stored can be checked by the physician for medical correctness and can be used to retrain the model.

The past 10 weeks have been difficult, but they have also been a tremendous opportunity to learn. I want to express my gratitude to Daniel English, my industrial supervisor, for their unwavering support over the past few weeks. I also like to thank my academic adviser Evgeny Mirkes for guiding throughout the journey and I want to extend my heartfelt gratitude to the director Dr. Andrey Morozov for the opportunity to study.

I would also like to express my sincere thanks to University of Leicester for their invaluable academic pursuit.

And finally I would like to thank my fellow project members Garima Shrestha, Suresh Kunchapu, Amaan Patel, Fabiha Choudhury for their invaluable suggestions and contributions to improve the project.