International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org || PP. 32-38

IoT Support System for Dementia Patients

Nagamani H Shahapure[1], Spoorthi Kulkarni[2], Shilpa V[3], Rajiv Ranjan Singh[4], Patel Kavan[5]

[1]*(Department of Information Science and Engineering, JSS Academy of Technical Education, Bangalore, India,*
[2]*(Department of Information Science and Engineering, JSS Academy of Technical Education, Bangalore, India,*
[3]*(Department of Information Science and Engineering, JSS Academy of Technical Education, Bangalore, India,*
[4]*(Department of Information Science and Engineering, JSS Academy of Technical Education, Bangalore, India,*
[5]*(Department of Information Science and Engineering, JSS Academy of Technical Education, Bangalore, India,*

Abstract: *IoT healthcare developments are widely seen as an enormous value to the elderly patients. The Internet of Things (IoT) is a concept or a system that uses networking technology to allow real-world items to connect and interact with one another. This technology is used in home automation, smart grid stations, healthcare systems, smart farming, transport services, smart buildings, and other applications. Patients' health is monitored by different sensors, IoT devices, and web applications connected to these devices through networking. Due to the increase in the number of patients with dementia, there is a spike in the need for assistance. Dementia in the elderly is one of the most devastating diseases, with symptoms such as loss of cognitive function. Cognitive problems can impact anyone, ranging from severe mental impairment to the incapacity to recall information. It can also cause the loss or failure of critical cognitive skills like communication. This study looks at the conclusions of the majority of studies that show how technology can help relieve caregiver stress, provide patient security, assist patients through reminders, and carefully monitor patient behavior and health. It's a difficult effort to assist dementia patients in speaking and living a full life. Natural Language Processing (NLP) may be useful in this situation (NLP). As a result, this research includes an experimental outcome of a communication aid that predicts the next words or phrases from a Dementia Patient's incomplete or stuttered conversation.*

Keywords—*Internet of Things, Dementia, Machine Learning Models, Next word Prediction*

I. Introduction

IoT has had a tremendous impact on human living in all fields, including medical, healthcare, industry, transportation, education, and agriculture, over the previous decade. The properties of the surrounding environment are monitored using sensors or actuators in this technique. The majority of them utilised communication technologies such as Wi-Fi and GSM to communicate with control centres and transmit data collected from the environment, as well as to aid in decision-making at remote control centres. Smart dwellings are awaited with bated breath by people all over the world

IoT healthcare solutions can accurately track people, machinery, specimens, and materials, as well as analyse and interpret data collected from a number of stakeholders, including hospitals, diagnosis, nursing homes, and the community. The Internet of Things enables physical things to perform, receive information, and coordinate their decisions by using a variety of technologies such as ubiquitous and pervasive computing, microcontrollers, intelligence technologies, sensor networks, TCP/IP, and domain-specific applications.

Patients with Alzheimer's disease, which has become the most common neurological disorder in the previous decade, are the subject of this research. It's a type of dementia that affects 95% of the elderly. Dementia is a chronic disease in which an elderly person's cognitive abilities deteriorate beyond what would be expected in a healthy younger person.

Recall, understanding, cognition, learning ability, logic, and consciousness are all affected by this disorder. Cognitive impairment is frequently coupled with, and sometimes preceded by, changes in emotional regulation, behaviour patterns, or motivation. Dementia has a wide range of effects on family members, caregivers, and society.

This type of illness causes a person to become oblivious because he or she is unable to perform daily tasks on their own and requires continual monitoring of their behaviour and health by a family member or caregiver. However, with Internet of Things capabilities, we should be able to independently study the behaviours and health status of these patients, lowering expenses and enabling for more quick reactions to these patients. These patients' homes are equipped with a variety of wearables, sensors, and actuators. These Internet of Things sensors are used to track their temperature, medication intake, and mobility. Several types of sensors, as well as actuators, are used for safe data transfer, and current protocols are also used. MQTT, WebSockets, and HTTP are some of the protocols that have been utilized under the Web of Things (WoT) umbrella. The data acquired from all these IoT devices were encrypted during transmission and storage on cloud servers. Patients' health problems have been monitored using a variety of approaches. One of these uses neural network models and Bayesian methods to monitor the patients on a real-time basis using IoT.

In the current context, home healthcare is progressing because the Internet of Things is helping to improve the medical management system for the elderly and those with chronic diseases. These patients must take pills on a regular basis and must be constantly monitored. Traditionally, dispensing pills is handled by the patients themselves or, if the patients are elderly, by a caretaker. When there are a lot of drugs, filtering them out might be tough, especially if a caregiver is assigned to a lot of patients with diverse medical histories. To tackle this question, a smart and secure medication box has been created, which is designed to handle and categorize six different medications. The Bio-sensor also includes temperature and pulse monitoring in the medication box.

Wandering behaviour is common in older people with cognitive deficits such as dementia. Dementia patient loses their sense of direction as the disease progresses. The introduction of special technologies such as IoT and RFID has made it possible to find patients easily. The Internet of Things (IoT) links countless intelligentgadgets to the cloud. These things are able to converse with one another.

Dementia sufferers are frequently taught how to use IoT, computation (AI), and automation technologies to monitor their health and assist them with normal chores such as socialisation, cooking, and dressing. Even older people and their caretakers can benefit from IoT and AI on regular basis. As a result, the dementia assist relieves caregivers' burdens while also providing patients with a high quality of life.

II. Literature Survey

Monitoring System

Khan et al. suggested and designed an IoT and RFID-based healthcare monitoring system. The output of this system has helped in various emergency medical cases. A mixture of microcontrollers and sensors is used in the suggested system to receive the results of unadulterated examinations, monitoring and also assess the patient's health status. [6]

In an emergency, Gupta et al. proposed an IoT-based health monitoring system for medical services. Because real-time collecting, recording, analyzing, and sharing of health-related data is done efficiently in the IoT cloud environment with this healthcare kit, health-related hazards are minimized. Sensors interrogated with this kit aid in the monitoring of blood pressure, temperature, and heartbeat, allowing the patient to avoid going to the hospital. The ultimate goal of these smart healthcare services is to deliver proper and efficient medical services to patients by gathering all information about the patient's present status and transmitting it to the doctor when necessary or in an emergency. [3]

Location, step count, and recognized activities were required forms of data to evaluate mobility and activity of the Dementia Patient.

The Mobility metrics is calculated using the set of location coordinates, GPS trajectories having a sequence of stays and movement, and the known home location. GPS sensors installed in IoT devices such as trackers and smart watches help in tracking the Patient's whereabouts. The recognized actions of the patient are calculated by combining accelerometer data and the data from different sensors. Steps are commonly counted via activity trackers and smart devices, which use onboard pedometers or accelerometer data to calculate the number of steps taken

Activity measurement is used to evaluate how active a person's daily life is in the context of behavioral monitoring for dementia patients. Active/walking time duration, number of walking bouts, and total steps per day are all examples of activity metrics. Google's activity recognition API data can be used to detect activity bouts. For the sake of recognition, each occurrence of activity is logged with a timestamp and a degree of confidence.

The health parameters such as heart beat, blood pressure, vitals, temperature are continuously monitored to alert the caretaker in case of any complications in the patient.

Remainder System

Srinivas et al. proposed an intelligent medical box in the IoT platform that is based on modern healthcare. This smart medical box works in tandem with sensors to monitor and diagnose the patient's health. The clever medical box has a wireless connection and an Android app that allows for easy contact between the nurses and the patients. As it is linked to the internet, medicine reminders are also sent through SMS, and it can even send notifications to a remotely placed guardian or caretaker in case of an emergency crisis. [3]

A paper on medication adherence was presented, which has a significant impact on healthcare facilities. For patients with amnesia, the author developed an IoT-based system for activity tracking to ensure medicine ingestion at the prescribed time. For end-to-end consistency, the networking layer contains a gateway structure.

The intelligent box for patients' medicine ingestion, this simulated environment is a superior option. [3]

An intelligent medication box was implemented to aid the elderly patients to remind them of the medication. The medication box collects the patient's information such as patient's names, pill quantities, dosage and pill names. The iMedBox send alerts or notifications to remind the patient to take medication. The iMedBox also beeps or lights on with LED for alerts.

The iMedBox is filled with pills by clicking on the insert button. The pill is later dispensed with correct dosage when Arduino sends signal at the time of medication. The Arduino Uno is an ATmega328-based microcontroller board. There are 14 digital input and output pins plus 6 analog inputs on this board. The Arduino board, which is powered by a 12V adaptor, is the pill box's brain. The Arduino controls pill container sub-boxes, pill refilling, and pill dispensing.

Tracking System

Infrared, ultra-sonic, Zigbee, wireless systems (WLAN), Bluetooth, RFID tags, and more technologies exist for indoor localization. Active Badge is a well-known infrared-based location tracking system. In the system, an infrared sensor network is installed in a structure, and a specially designed tag with an infrared LED transmits a modulated infrared signal to a sensor. [4]

For location in the IoT, RFID is a preferred technique because it is low-cost and provides a highly reliable identifying mechanism. Due to transmitter fading in an interior setting, RFID localization faces a number of interference issues, notably in passive RFID. Passive RFID tags have been in use to detect the location of Dementia patients. As a result, each old person must always wear a personal tag. Tag positions include (a) the neck, (b) the ankle, (c) the wrist, and (d) the shoulders.

Using customized global positioning system (GPS) kits, smartphones, smartwatches, and ankle-worn accelerometers, mobility and activity features were calculated. Smartphones and wearables have been used to track the activities of older people, their daily step counts, and distance traveled. [2]

Indoor localization is particularly useful for triggering the onset of an elderly fall or elopement related to dementia. Indoor localization poses a variety of problems for IoT, according to various studies. Signals may be affected by interference or multipath fading, for example, lowering the localization accuracy. [4]

Antenna are fixed in different rooms inside the house. When the patient enters the bandwidth of a single antenna, it is presumed that the patient's location is the same as the antennas. The target is presumed to be near the antenna that gets the strongest signal if more than one antenna senses an individual. An elderly person located in a region near the front door is regarded as an emergency case. The old would have crossed the antenna in the corridor by that time and would no longer be visible in the system, but warnings are issued to indicate that an elderly person is at risk and prone to falling by sending alerts to caretaker and family member.

III. Objective

A communicative aid is required as it becomes harder for patients with dementia to speak as the illness progresses. The paper proposes a communicative aid for dementia patients which predicts the next word or phrases from the patient’s incomplete or stuttered sentence.

IV. Methodology

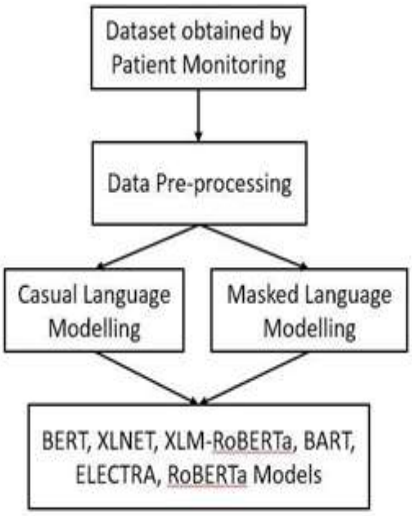
Data Collection

The Dementia patients are monitored to obtain all the data of their conversations. The speech recognition converts the speech signal to text and is stored in the dataset. The monitoring device learns new conversational sentences from the patient daily to predict the next word or phrase accordingly. The dataset of each dementia patient differs because of their varied lifestyle, language, vocabulary usage, and fluency. However, the dataset used in this implementation is obtained from conversations with a healthy person. The result would be with the same accuracy when Dementia patients’ conversations are used as the process remains the same.

Data Pre-processing

The data must first be transformed into a format that the model can understand before it can be used in the model. Raw text or audio is incomprehensible to a model. These numbers must be converted to tensors before they can be used.

Tokenizers are the most significant tool for textual data processing in natural language processing (NLP). Tokenizers start by breaking down text into tokens according to a set of rules. Tokens are converted to numbers, which are subsequently used to build tensors for model input. Any extra inputs that a model requires are also added by the tokenizer.



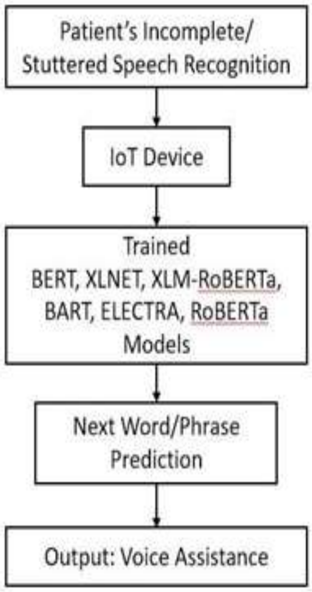


Fig 1. Data Work Flow   Fig 2. Communicative Aid Work Flow

Language modeling

Language modeling predicts words in a sentence. There are two forms of language modeling.

Casual Language Modelling

Only tokens on the left can be addressed by the model, which predicts the next token in a sequence of tokens. When it comes to text generation, causal language modelling is commonly applied. After tokenizing all of the sentences in our dataset for causal language modelling, we'll concatenate them all (CLM). Then we'll break them down into sequences of various lengths. This manner, the model will acquire contiguous text chunks regardless of how many original texts there are in the dataset. The labels will be identical to the inputs, but will be shifted to the left. We can evaluate our model and determine its perplexity on the validation set once the training is completed.

Masked language modeling

The model can predict a masked token in a sequence and attend to tokens in both directions. We just have to make predictions for the masked tokens (which make up 15% of the total here) while having access to the entire tokens for the MLM aim. Because we only have to make predictions for the masked tokens (which constitute 15% of the total here) while having access to the rest of the tokens, the perplexity is substantially smaller than for the CLM objective.

Machine Learning Models

The following models were trained on the dementia patient dataset to predict the next word.

BERT (Bidirectional Encoder Representations from Transformers)

It's a bidirectional transformer that was trained using a combination of masked language modelling and next sentence prediction techniques. By conditioning all layers on both the left and right context, it is designed totrain deep bidirectional representations from unlabelled text. BERT improves the accuracy to 86.7 percent and raises the GLUE score to 80.5 percent (7.7% absolute improvement) (4.6 percent absolute improvement).

XLnet

XLnet is a Transformer-XL model that was trained using an autoregressive technique. On 20 tasks, XLNet surpasses BERT, frequently by a substantial margin. The XLnet model is one of the few that does not have a sequence length limit.

RoBERTa

The impact of numerous crucial hyperparameters and training data size is thoroughly measured by BERT training, according to a study. BERT was discovered to be severely undertrained, and it can now match or outperform every model published after it. The implementation is identical to that of the BERT model, with minor changes to the embeddings and a configuration for RoBERTa trained models.

XLM RoBERTa

XLM RoBERTa is a large multilingual language model that can be trained in over 100 languages. It is not necessary for language tensors to comprehend which language is used; instead, the proper language should be determined from the input ids. RoBERTa's implementation is similar.

BART

BART uses a seq2seq/machine translation architecture that incorporates a bidirectional encoder and a left-right decoder (similar to BERT) (like GPT). The training entails randomly altering the source sentence sequence and replacing text gaps with mask tokens. BART is particularly good at text generation, but it's also good at comprehension. With comparable training resources, it equals RoBERTa's GLUE and SQuAD performance.

ELECTRA

ELECTRA is a training method that involves training two transformer models which are the generator and discriminator. The generator is trained as a masked language model because its job is to substitute tokens in a sequence. The discriminator tries to figure out which tokens in the sequence were substituted by the generator. This method scales well, performing similarly to RoBERTa and XLNet while consuming less than a quarter of their compute and outperforming them when using the same computation.

Voice Assistance

Dementia patients will be assisted with the help of IoT devices such as smartphones or smart watches. Both the input and output will be in the form of speech. The predicted next word is voiced out in full sentences by the device.

V. Experiment And Result

The above models are tested for next word prediction when an incomplete sentence is given as an input. Currently the system can predict maximum of k=10 words for each model. We can vary the number of predictions from 1 to 10 range. In the current implementation voice input can be taken to predict the word. Along with that, we can upload an audio file containing an incomplete sentence to predict the next word. In casual language modelling, when the incomplete sentences given as input, the next word is predicted by each model. The models BERT, XLM-RoBERTa, BART and RoBERTA seems to provide more accurate results in casual language modelling. In case of Masked language modelling, the models predict the missing word in the sentence. The concept of number of predictions is implemented as same as that of CLM. The models BERT, XLM-RoBERTa, BART, ELECTRA and RoBERTA seems to provide more accurate results in masked language modelling.

Any of these models providing the better accuracy based on the dataset, can be used to predict the next word for Dementia Patient’s incomplete sentence.

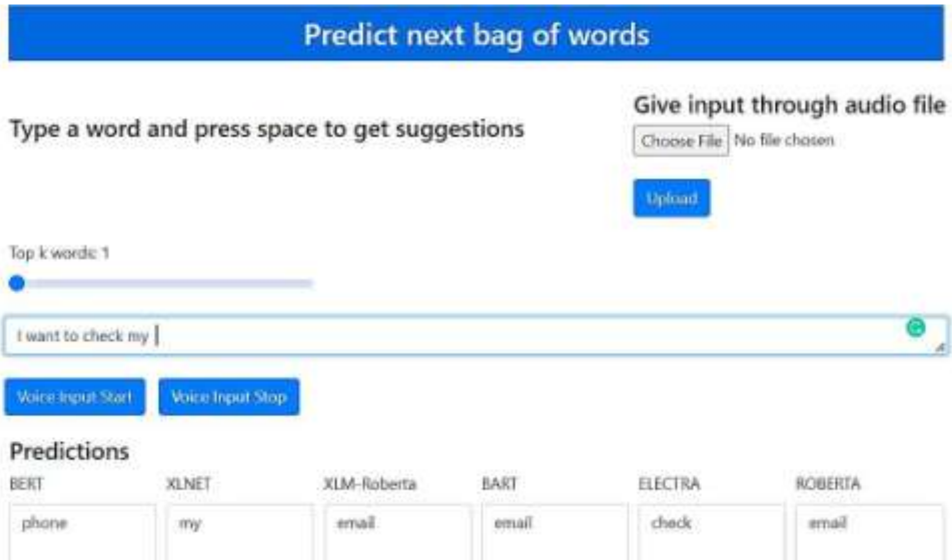


Fig 3. Implementation of Casual Language Modelling

Fig 4. Implementation of Masked Language Modelling

VI. Challenges

Despite the fact that technology benefits patients, several hurdles must be overcome in order for patient care to be more effective. The most difficult task is determining how to collect, store, process, and analyse the huge volumes of data received by healthcare providers.

To effectively analyse the data collected, which may or may not be present at the moment, several artificial intelligence systems are necessary. Furthermore, it is challenging to synchronise electronic health records obtained via IoT-based systems with manual records based on a patient's visit to the doctor. They include the following:

- Obtaining the basic data by monitoring the patient's daily routine for a period of time.
- Obtain additional patient-specific datasets from sensors, doctors, and caregivers.
- Regularly receiving and processing large amounts of data.
- Personalize, produce, and prompt the word that is closest in meaning.
- Come up with a unique way to carry out the actions outlined above.
- The most visible open issues are data privacy and security.
- There is a growing demand for IoT devices, as well as a rising cost.

VII. Conclusion

In the field of medicine, technology has begun to play a significant role. Various IoT Innovations and Machine Learning Methods are being utilized to care for patients with dementia to improve their lifestyle. This is achieved by monitoring the patient's behavioural patterns and tracking their daily routines to assist the patients.

The researchers have summarized that the smart technologies can help patients with communication, daily support, and safety. Future improvements in dementia staff aids could include the ability to communicate in several languages, manually schedule reminders other than medication, monitor all of the patient's health indicators, and much more. The drawback of these IoT systems would include the inability to recognize and store the massive amount of data that is collected throughout the process. The paper also discusses how to care for dementia patients once the condition has been identified, to make their life safer and more comfortable and make the process easier for their caretakers and family members.

References

[1] Rozita Jamili Oskouei, Zahra MousaviLou,Zohreh Bakhtiari,and Khuda Bux Jalbani3 "IoT-Based Healthcare Support System for Alzheimer's Patients" Published 17 October 2020

[2] Julia Rosemary Thorpe; Birgitte Hysse Forchhammer ; Anja M Maier; "Development of a Sensor-Based Behavioral Monitoring Solutionto Support Dementia Care" 2019

[3] B.Ayshwarya, R.Velmurugan, "Intelligent and Safe Medication Box In Health IoT Platform for Medication Monitoring System with Timely Remainder" 2021

[4] Muhammad Wasim. Raad , Mohamed Deriche , Olfa Kanoun "An RFID-Based Monitoring and Localization System for Dementia Patients"

[5] Viktoria Hoel, Carine Mendom Feunou and Karin Wolf-Ostermann "Technology-driven solutions to prompt conversation, aid communication and support interaction for people with dementia and their caregivers: a systematic literature review"

[6] Mohammad Nuruzzaman Bhuiyan , Dr. Md. Mahbubur Rahman, Md Masum Billah , Dipanita Saha , "Internet of Things (IoT): A reviewof its enabling technologies in healthcare applications, standards protocols, security and market opportunities" february 17, 2021

[7] Lampros C. Kourtis, Oliver B. Regele, Justin M. Wright and Graham B. Jones, "Digital biomarkers for Alzheimer's disease: the mobile/ wearable devices opportunity"

[8] Jacob Devlin, Ming-Wei Chang, Kenton Lee, Kristina Toutanova, "BERT: Pre-training of Deep Bidirectional Transformers for LanguageUnderstanding"

[9] Zhilin Yang, Zihang Dai, Yiming Yang, Jaime Carbonell, Ruslan Salakhutdinov, Quoc V. Le, "XLNet: Generalized Autoregressive Pretraining for Language Understanding".

[10] Alexis Conneau, Kartikay Khandelwal, Naman Goyal, Vishrav Chaudhary, Guillaume Wenzek, Francisco Guzmán, Edouard Grave, Myle Ott, Luke Zettlemoyer, Veselin Stoyanov, "Unsupervised Cross-lingual Representation Learning at Scale".

[11] Mike Lewis, Yinhan Liu, Naman Goyal, Marjan Ghazvininejad, Abdelrahman Mohamed, Omer Levy, Ves Stoyanov and Luke Zettlemoyer on 29 Oct, 2019, "BART: Denoising Sequence-to-Sequence Pre-training for Natural Language Generation, Translation, and Comprehension ".

[12] Kevin Clark, Minh-Thang Luong, Quoc V. Le, Christopher D. Manning, "Electra: Pre-Training Text Encoders As Discriminators Rather Than Generators".

[13] Yinhan Liu, Myle Ott, Naman Goyal, Jingfei Du, Mandar Joshi, Danqi Chen, Omer Levy, Mike Lewis, Luke Zettlemoyer, Veselin Stoyanov, "RoBERTa: A Robustly Optimized BERT Pretraining Approach ".