AI Stroke Detection and Emergency Response System

Joel Francis Xavier[1], Intan Farahana Binti Kamsin[2], Zety Marlia Zainal Abidin[3], Hemalata Vasudavan[4]
[1,2,3,4]Asia Pacific University of Technology and Innovation, Technology Park Malaysia, Bukit Jalil, Kuala Lumpur, Malaysia.
[1]joelfrancis573@gmail.com, [2]intan.farahana@staffemail.apu.edu.my, [3]zety@staffemail.apu.edu.my, [4]hemalata@staffemail.apu.edu.my

Abstract **- Deaths caused by stroke from patients failed to seek help increases. Most of them don't even realize they have a stroke attack in the first place. Before a stroke takes place, an arrythmia of the heartbeat takes place beforehand. Detecting that can bring awareness to an individual beforehand and overcome a stroke attack that leads to death. This research paper has the aim to propose an AI device that immediately alerts the medical authorities before a stroke attack takes place. For the target population, mainly consists of Vascular Neurologists, patients that went through stroke attacks and Telemedicine engineers. The population will be sampled using stratified sampling and dividing them into subgroups. Besides, the data collection method used is the survey approach. In conclusion, it is possible that AI Stroke Detection system which is wearable can be used in telemedicine to provide real-time monitoring and healthcare. For future recommendations, special optimized healthcare plans can be implemented in the system to suggest the patients to change their current lifestyle to a healthy one depending on their medical background.**

Index Terms **- Stroke, Telemedicine, Artificial Intelligence**

1.0 Introduction

In this era of globalization, death is a very common thing among the population. One of the heart-breaking deaths are from stroke attacks. Every 3.5 minutes, someone dies of stroke and every 40 seconds someone gets stroke [1]. How heartbreaking it is yet many people fail to understand the impact that stroke is making. A research conducted [2], states that if individuals follow a healthy lifestyle, the chance of getting a stroke is 80% lower than those who does not follow a healthy lifestyle. This paper is all about a solution to taking premeasures to prevent severity level of helpless death due to stroke.

2.0 Literature Review

2.1 Research Domain

2.1.1 Telemedicine

Telemedicine is defined as any medical attention or medical consultation that is conducted in a distance. Back in the day, Doctors used to attend patients either in their clinic or by going to their houses. Ever since telemedicine have evolved, doctor-patient interaction evolved into telecommunication means [3].

During the COVID-19 pandemic, telemedicine was all the reason to exist and used. Physical contact was not advisable therefore communicating through telecommunication means was necessary [4].

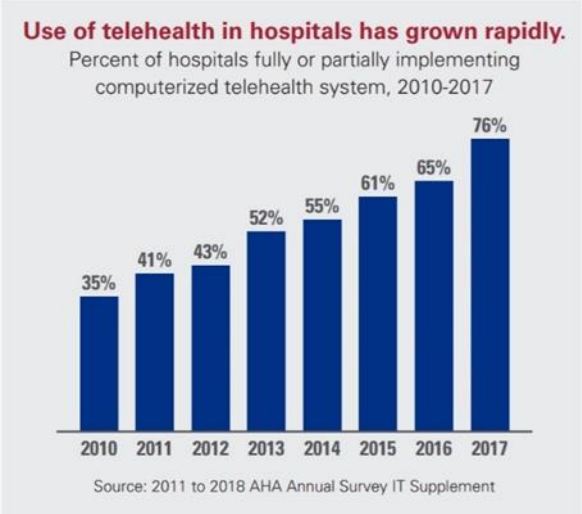

Figure 1: Bar Chart for Usage of Telemedicine from 2010 to 2017

Depending on telemedicine treatments itself is not advisable. Based on research [5], while the doctors communicate with patients via telemedicine in alternate to in-clinic patient visits, its advised that doctors also must meet their patients directly to get detailed insights and to improve the workflow.

Telemedicine can be used as a temporary mean to get emergency help or in a situation where meeting directly is impossible. When it comes to Stroke attacks and caring for stroke patients, tele-stroke clinics helps in encountering neurological emergencies promptly [6].

However, the usage of telemedicine has been shown to reduce cost of the patients. In research conducted [7], the patients feel motivated of using telemedicine due to lower costs and need not to travel to healthcare centers to seek health.

When it comes to utilizing telemedicine and AI, there are four main trends. Patient monitoring, healthcare information technology, intelligent assistance in diagnosis and information analysis [8].

In conclusion, Telemedicine so far can only seek medical help from a distance but haven't been used to detect an upcoming stroke in patients in real time. Therefore, in this research, all the aspects of telemedicine that were discussed, will be used in implementing a device that uses telemedicine to seek help and assistance even before patients get stroke by detecting the stroke earlier on.

2.1.2 Artificial Intelligence in detecting Atrial Fibrillation

Artificial Intelligence (AI) is a computer-programmed system or a robot that is used to perform tasks equally to how a human would think and do [9]. The popular term used in AI is Machine Learning. Deep learning being the subset of Machine Learning which has evolved into Convolutional Neural Networks (CNN) has used the technology of neural networks to adapt and address complicated tasks [10].

Now we know that what is Artificial Intelligence, before we jump into how it detects Atrial Fibrillation, let us come into what is Atrial Fibrillation. Atrial Fibrillation is an arrhythmia that is currently common, that it affects 33 million people worldwide and will double over the next 40 years [11].

Various Deep Learning Models have been created to detect Atrial Fibrillation, but to bring it into clinical practice is still inconsideration. A retrospective study conducted [12] proves that Deep Learning Models correctly diagnosed Atrial Fibrillation using a variety of ECGs. The findings suggested that a transparent artificial intelligence technique may be used to the Deep Learning Model utilizing ECG to improve its transparency for clinical application.

In contrast, another research conducted, states that ECGs can differ from person to person with different backgrounds. Patients with some sort of heart disease and older age, compare to patients with no heart disease and younger age show different ECG readings. Therefore, the gap between the age and background diseases can result in poor Atrial Fibrillation detection. This is where Deep Learning Models are implemented to learn from past detections from the patients from different backgrounds [13].

The above research is proven by another research conducted [14], where patients are divided into subgroups according with the clinical history where one group consists of patients that got Atrial Fibrillation at least once and another group consists of ECG interpretation of sinus rhythm. Once their ECGs were recorded and taken, AIs were tested in two different phases, one being the behavior of AI models for age-sex-specific groups of patients, while the second looks at state-of-the-art AI models with varied age distributions in datasets. Finally, AI approaches were used to visualize the features of the ECG data in the recorded data. As a result, it is possible to pinpoint the most important regions of the ECG data for the model to forecast the existence or absence of AF in the future.

Thus, in conclusion, AIs can be used in detecting upcoming or existed Atrial Fibrillation but haven't been implemented yet in the medical world due to the less amount of research done. In this research, Artificial Intelligence Deep Learning models will be used in detecting Atrial Fibrillation beforehand. Finally, we use AI approaches to visualize the features of the ECG data in our test sets. As a result, we can pinpoint the most important regions of the ECG data for our model to forecast the existence or absence of AF in the future. We can quantify the contribution of each lead for AF prediction and identify disparities among age-sex-specific groups of patients using the information supplied by feature visualization.

2.1.3 Wearable Device

A Wearable Device is a technology-based device that can be worn by any individual. It can vary from size from as small as a smart earring to a smart shirt. The use of this wearable devices to monitor physical activity and even health risks can increase up to fivefold every 5 years [15].

Medical devices have been reduced in size and wearable. The real challenge here is reducing the size and optimizing it for non-medical professional use in unfavorable conditions [16].

As the world's older population rises, numerous chronic and acute diseases become more prevalent, and the medical sector is rapidly evolving to meet the need for point-of-care (POC) diagnostics and real-time monitoring of long-term health issues. Wearable medical helps in meeting these needs [17].

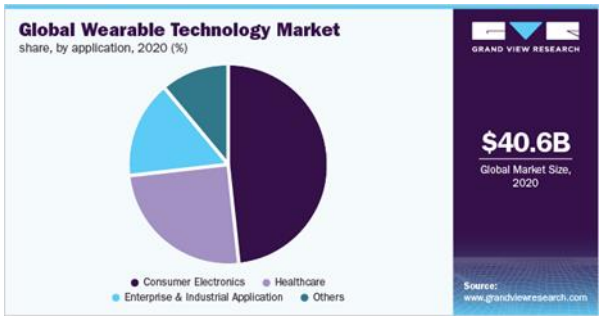

Figure 2: Global Wearable Technology Market in year 2020

The above figure 2 shows that wearable devices in the Global Wearable Technology Market for healthcare have gotten the second most used reason for in the year 2022. This shows the dependency for wearable devices in the healthcare sector [18].

According to research made [19], wearable medical devices have so far been developed for use on all parts of the human body, including the head, limbs, and torso. The four application areas for these devices are health and safety monitoring, chronic illness management, disease diagnosis and treatment, and rehabilitation. However, the wearable medical device market, on the other hand, is now hampered by several important constraints, including difficulties in designing user-friendly solutions, security and privacy concerns, a lack of industry standards, and a range of technological limitations.

However, Healthcare Wearable Devices are still in the room for further development due to the limitations in it. For example, the data received by the sensors in the wearable device might vary due to the interfering fact of distortion and noise.

Users might not be in a favorable condition always. Constant movement and environmental factors must always take into consideration when analyzing the data gathered from the healthcare wearable devices [20].

Therefore, in conclusion, healthcare wearable devices can be used in real-time monitoring and diagnosis. In this research, we will combine the wearable device with AI Deep Learning Models and seek help using the means of telemedicine.

2.2 Similar System

2.2.1 Apple Watch Fall Detection

Apple Watch Fall Detection is a feature available in Apple Watch SE or Apple Watch Series 4 and above. The Apple watch does two functions in fall detection. It detects whether the user had a fall and alert the emergency authorities. Here is how it works. When the user had a fall or the user is still at one place while the watch is on for about one minute, it starts a countdown of 30 seconds. During this 30 second, it taps the wrist of the user and release a warning alarm. As time goes by, the alarm gets louder so that the user will wake up to the sound or someone nearby can hear it. In between this countdown, the user can click cancel if not after 30 seconds, the apple watch will contact emergency services and inform the users status and location [21].

Figure 3: Apple Watch Device

Figure 4: Apple Watch Fall Detection Interface

The Figure 4 above shows the interface inside the Apple Watch that appears when one is suspected of immobility. The user has an option of responding to a SOS call or the "I'm OK" option to stop the 30 seconds countdown before Apple Watch automatically calls the emergency authorities.

2.2.2 Kardia Mobile

AliveCor's KardiaMobile is an electrocardiogram (ECG) which is compatible with Smartphones for data collection and analysis that helps to detect Atrial Fibrillation from the comfort of your home [22]. Most mobile devices can accommodate the KardiaMobile ECG. To capture an ECG, it just sits on the user's fingertips or chest. Electrical impulses from the user's fingers are converted into ultrasonic signals and delivered to the mobile device's microphone using AliveCor's patented technology.

Figure 5: ECG Patch Monitor and Interface

Figure 6: App Report Interface

The figure 5 above shows the ECG monitor that is connected to the smartphone is collecting data from the fingertips and transmitting them to the smartphone for a visual interpretation of the heartbeats. The figure 6 shows the types of states the app will show to alert the user of a possible Atrial Fibrillation for example.

2.3 Comparison Table

Similar Features /Component	Apple Watch	KardiaMobile
Telemedicine	\	
Artificial Intelligence	\	\
Wearable	\	
Smartphone Connected	\	\
Price	Affordable	High
FDA Approved	\	\
Detects Atrial Fibrillation		\

Table 1: Comparison Table between Apple Watch and Kardia Mobile

The Table 1 above shows all the features and components for the similar systems discussed earlier. The features that are compared are Telemedicine, Artificial Intelligence, Wearable, Smartphone Connected, Price, FDA Approved and whether it detects Atrial Fibrillation.

3.0 Problem Statement

Stroke is a life-threatening medical condition that has one of the highest risks of death. Even if it is not an acute stroke, the risk of death is still there in a study [23]. In the same research paper, it is also stated that as the number of years increases from the first stroke experience, the percentage of cumulative risks for death increases. In another study conducted, it states that an individual who diagnosed with stroke will face cognitive impairment approximately after 3 months of stroke and leads to other poor outcomes like disability [24]. The real problem is not that people having stroke, it is that people don't seek immediate attention when they get stroke. In research conducted [25], Stroke patients who do not seek immediate attention is said to have several reasons. Fear of the aftereffects of stroke that impacts friends and families plays a huge role. Rumors about Stroke treatments also plays a role from avoiding medical attention. It is said that they lack the knowledge of seriousness about Stroke. Therefore, investing in the research of detecting stroke and alerting emergency medical attention by auto is crucial and would save a ton of lives.

4.0 Research Aim

This Research aims to propose an AI device that immediately alerts the medical authorities before a stroke attack takes place.

5.0 Research Objectives

i) To detect the atrial fibrillation that takes place beforehand.
ii) To auto call 911 once atrial fibrillation is detected.
iii) To inform details of the location of the patient for immediate help.

6.0 Research Significance

The result in conducting this research would make a significant contribution to helpless patients that seek help during stroke attacks. The patients no need to worry about seeking help during attacks cause the help call will be done even before a severe symptom starts to show through this research. Besides, the research will also benefit researchers. The researchers can have an insight on how artificial intelligence can be used for emergency responses in the convenient way possible.
Lastly, this research will also contribute to the medical authorities as it will reduce the number of patients dying due to not reaching out when a stroke attack takes place.

7.0 Methodology

7.1 Identify Target User

The target users for this research would mainly consists of Vascular Neurologists, patients that went through stroke attacks and Telemedicine engineers. They were chosen cause because they would contribute a lot in coming up with the device that detects stroke attacks even before they arise, enough to reduce the number of deaths that is caused by stroke attacks [25].

7.2 Sampling Method

For the sampling method, the stratified sampling method was used in this research to cover a vast number of respondents in a short time that have a known non-zero chance of getting selected due to the fact that it's a random selection. In addition to that, it also prevents biasness among the respondents. The population will be divided into different subgroups and then selecting the subject from each group in an equal manner [26].

7.3 Sampling Size

The survey that is created will be implemented with 200 respondents that consists of doctors, stroke patients and telemedicine engineers. So that the voices can be represented equally in each divided subgroup.

7.4 Data Collection Method

As stated above, the data collection method that was chosen were surveys. The reason is to obtain data from a large number of respondents in a limited time frame. In addition to that, the questions created in the survey are very straightforward and easy to understand due to the fact that the respondents vary from different age groups and backgrounds.

The contents of the survey will include 5 multiple choice questions, 3 open ended questions and 2 Likert scales questions. The questions will be created by adapting some questions from various surveys and the rest will be created based on the needs of the research. Before the questions will be given out, a pilot test of the questions will be taken place to know and evaluate the quality of the questions of the survey.

Once Data is collected from the respondents, the data will now be analyzed to contribute to the feasibility of telemedicine and how it benefits the stroke patients in preventing deaths.

8.0 Overview of Proposed System

The below Figure 7 explains the four main functions of the system. The system monitors the heartbeat of the patient. The System then detects any possible Atrial Fibrillation through the arrythmia pattern of the heartbeat. If there is an Atrial Fibrillation detected, the system then calls the emergency authorities for help together with the sending the location of the patient. The Emergency Authorities will then be on call with the patient and advise them in steps necessary to take while the emergency team arrives at the location with an ambulance.

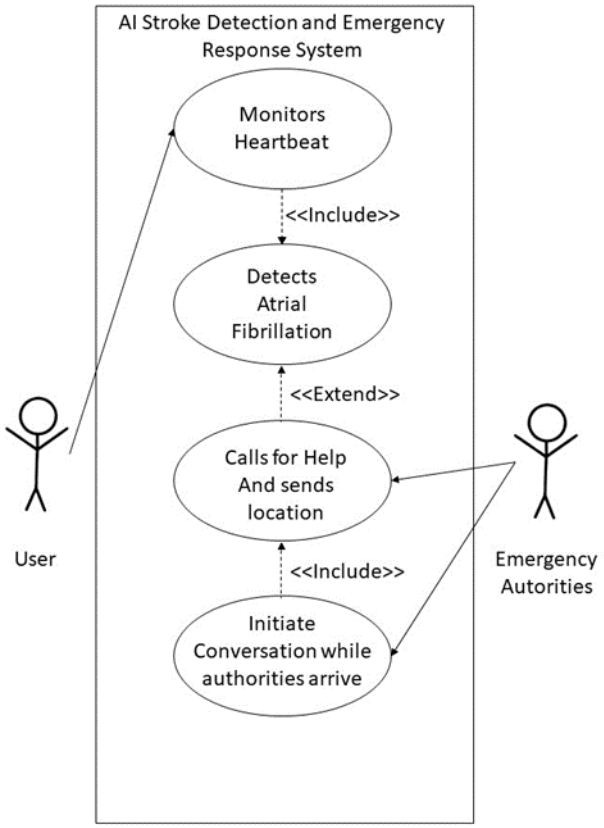

Figure 7: Use Case Diagram for the AI Stroke Detection and Emergency Response System

9.0 Conclusion

Artificial Intelligence in the use of telemedicine is still under development in the healthcare world. Furthermore, connecting it with the ability to detect Atrial Fibrillation to prevent Stroke attacks beforehand hasn't been come into consideration despise no studies have proven the effectiveness of this fusion.

In this research paper, the feasibility study of detecting stroke beforehand by detecting the possibility of Atrial Fibrillation using AI and telemedicine and if detected, reaching out to the emergency authorities for help will change the lives of many patients by reducing the possibility of getting stroke and will benefit the medical organization by speeding the process of diagnosis in an easy and effective manner. This will open a start for researchers to further develop this system created in the future. Medicine and Technology will continue to emerge steadily over the years.

10.0 References

[1] Stroke Facts | cdc.gov. (2022, April 5). Centers for Disease Control and Prevention. https://www.cdc.gov/stroke/facts.htm \

[2] Spence, J. D. (2013). Intensive risk factor control in stroke prevention. F1000PrimeReports, 5. https://doi.org/10.12703/p5-42

[3] Wootton, R. (2001). Recent advances: Telemedicine. BMJ, 323(7312), 557–560. https://doi.org/10.1136/bmj.323.7312.557

[4] Patterson, V. (2020). Neurological telemedicine in the COVID-19 era. Nature Reviews Neurology, 17(2), 73–74. https://doi.org/10.1038/s41582-020-00438-9

[5] Boxer, R. J. (2019). Advantages and utilization of telemedicine.mHealth,5,12. https://doi.org/10.21037/mhealth.2019.04.02

[6] Iqbal, N. (2021). Utility of telemedicine in ophthalmology clinic during COVID-19 era. Biomedical Research and Clinical Reviews, 3(3), 01–03. https://doi.org/10.31579/2692-9406/049

[7] Mishra, V. (2020). Factors affecting the adoption of telemedicine during COVID-19. Indian Journal of Public Health, 64(6), 234. https://doi.org/10.4103/ijph.ijph_480_20

[8] Pacis, D. M. M., Subido, E. D. C., & Bugtai, N. T. (2018). Trends in telemedicine utilizing artificial intelligence. AIP Conference Proceedings. https://doi.org/10.1063/1.5023979

[9] Copeland, B. (2022, March 18). artificial intelligence. Encyclopedia Britannica. https://www.britannica.com/technology/artificial-intelligence

[10] Chassagnon, G., Vakalopolou, M., Paragios, N., & Revel, M. P. (2019). Deep learning: definition and perspectives for thoracic imaging. European Radiology, 30(4), 2021–2030. https://doi.org/10.1007/s00330-019-06564-3

[11] Wijesurendra, R. S., & Casadei, B. (2019). Mechanisms of atrial fibrillation. Heart, 105(24), 1860–1867. https://doi.org/10.1136/heartjnl-2018-314267

[12] Jo, Y. Y., Cho, Y., Lee, S. Y., Kwon, J. M., Kim, K. H., Jeon, K. H., Cho, S., Park, J., & Oh, B. H. (2021). Explainable artificial intelligence to detect atrial fibrillation using electrocardiogram. International Journal of Cardiology, 328, 104–110. https://doi.org/10.1016/j.ijcard.2020.11.053 \

[13] Wolters, F. J. (2020). An AI-ECG algorithm for atrial fibrillation risk: steps towards clinical implementation. The Lancet, 396(10246), 235–236. https://doi.org/10.1016/s0140-6736(20)31062-x

[14] Melzi, P., Tolosana, R., Cecconi, A., Sanz-Garcia, A., Ortega, G. J., Jimenez-Borreguero, L. J., & Vera-Rodriguez, R. (2021). Analyzing artificial intelligence systems for the prediction of atrial fibrillation from sinus-rhythm ECGs including demographics and feature visualization. Scientific Reports, 11(1). https://doi.org/10.1038/s41598-021-02179-1

[15] Strain, T., Wijndaele, K., Dempsey, P. C., Sharp, S. J., Pearce, M., Jeon, J., Lindsay, T., Wareham, N., & Brage, S. (2020). Wearable-device-measured physical activity and future health risk. Nature Medicine, 26(9), 1385–1391. https://doi.org/10.1038/s41591-020-1012-3

[16] Glaros, C., & I. Fotiadis, D. (2005). Wearable Devices in Healthcare. Intelligent Paradigms for Healthcare Enterprises, 237–264. https://doi.org/10.1007/11311966_8

[17] Guk, K., Han, G., Lim, J., Jeong, K., Kang, T., Lim, E. K., & Jung, J. (2019). Evolution of Wearable Devices with Real-Time Disease Monitoring for Personalized Healthcare. Nanomaterials, 9(6), 813. https://doi.org/10.3390/nano9060813

[18] Grandviewresearch. (2020). Wearable Technology Market Size Analysis Report 2028. Grand View Research. https://www.grandviewresearch.com/industry-analysis/wearable-technology-market

[19] Lu, L., Zhang, J., Xie, Y., Gao, F., Xu, S., Wu, X., & Ye, Z. (2020). Wearable Health Devices in Health Care: Narrative Systematic Review. JMIR mHealth and uHealth, 8(11), e18907. https://doi.org/10.2196/18907

[20] Iqbal, S. M. A., Mahgoub, I., Du, E., Leavitt, M. A., & Asghar, W. (2021). Advances in healthcare wearable devices. Npj Flexible Electronics, 5(1). https://doi.org/10.1038/s41528-021-00107-x

[21] Apple. (2022, March 31). Use fall detection with Apple Watch. Apple Support. https://support.apple.com/en-us/HT208944

[22] AliveCor. (2022). AliveCor. https://www.kardia.com/

[23] Brønnum-Hansen, H., Davidsen, M., & Thorvaldsen, P. (2001). Long-Term Survival and Causes of Death After Stroke. Stroke, 32(9), 2131–2136. https://doi.org/10.1161/hs0901.094253

[24] Patel, M. D., Coshall, C., Rudd, A. G., & Wolfe, C. D. A. (2002). Cognitive Impairment after Stroke: Clinical Determinants and Its Associations with Long-Term Stroke Outcomes. Journal of the American Geriatrics Society, 50(4), 700–706. https://doi.org/10.1046/j.1532-5415.2002.50165.x

[25] Mackintosh, J. E., Murtagh, M. J., Rodgers, H., Thomson, R. G., Ford, G. A., & White, M. (2012). Why People Do, or Do Not, Immediately Contact Emergency Medical Services following the Onset of Acute Stroke: Qualitative Interview Study. PLoS ONE, 7(10), e46124. https://doi.org/10.1371/journal.pone.0046124

[26] Parsons, V. L. (2017). Stratified Sampling. Wiley StatsRef: Statistics Reference Online, 1–11. https://doi.org/10.1002/9781118445112.stat05999.pub2