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Enhancing EHR System for Disease Diagnosis and Monitoring

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***Abstract*—Big data has been harnessed through visualization by different sectors to help in making the right decisions. This could also find application in diagnosis decision-making by medical practitioners. This paper focused on the development of a web app dashboard that serves as a diagnostic assistant tool for medical practitioners which is mostly useful in emergency cases where the patient in question cannot completely respond to the questions of the medical practitioner. Also, the webapp gives a graphical display of the required patient's historical data (heart rate data (HR), accelerometer data (ACC) and contact data (C)) stored in a database thereby giving the clinician insights on what could possibly be the previous or underlying ailments of the patient they are trying to diagnose per time. For the data pipeline architecture, the Lambda architecture was adopted with little modifications while the data source used for this research was from the wearable technology developed by Apple watch. Google drive was used for data storage. The designed app showed the relevance of wearable technology in providing health related data, the importance of storing, accessing and visualizing such data for diagnosis of patients especially in emergency situations. Based on the result, the study concluded that the web app comes in handy, in situations where there is a communicable disease like covid-19 and it is also important to monitor the heart rate of the patient through the dashboard without the medical practitioner needing to move close to the patient in question. This webapp could be modified to be applicable in real-time situations like this.**

Keywords— Big data, visualization, web app

I. INTRODUCTION

Big data through visualization has been found applications in different sectors for insights and decision making. This ranges from health, academics, sport, finance, and so on. Recently, it has now been adopted in the health sector. This has been implemented through the development of dashboards. This includes the electronic health record (EHR) or the health information system (HIS) which assists in the day-to-day management of operations in a hospital [19] and also in monitoring the emergency department [8].

The use of visualization could become an essential part of health care. One of the key areas of research regarding health care is the visualization of patient records from the electronic health record (EHR) data, as it can aid in clinical care, medical research, and patient-physician communication [3]; [20]. However, the development of the dashboard has contributed immensely to the visualization of patient data (health records). [2], asserted that as a disease progresses, each patient's clinical characteristics and symptoms change and are influenced by lifestyle choices and medicinal therapies. Even between individuals with comparable demographic trends, medical profiles, family histories, and disease loads, these differences vary significantly. They further discussed that the patient-specific intervention a doctor includes in a treatment plan depends a lot on how the patient's sickness is progressing [2]. Generally, making the decision can be categorized into three forms, which are structured, unstructured and semi-structured. The decision-maker in the unstructured decision type often use discretion, analysis, and knowledge to resolve the issue. While in the case of structured decision type there are procedures to manage the process, they are repeated and normal, so managers (physicians) do not require to address every circumstance (health issues) as if it were brand-new. Only a portion of the problem

in the semi-structured decision type has a definitive solution offered by the accepted approach [6]. Software for electronic health records (EHRs) is frequently used to obtain data based on some parameters which includes fluid inputs and outputs, laboratory results, mental states, diagnostic reports, pharmaceutical dosages, patient transfers, and other aspects of health status along with longitudinal data [2].

Public health challenges have no doubt possess lot of threats to human existence, both communicable and non-communicable diseases have resulted in various disabilities as well as death to people living with them. [1] identified that teenagers' mortality from non-communicable diseases has significantly decreased between 1990 and 2019, but the rise in the number of years life lost to various ailments and the weight of their years with impairments is alarming. The disparities by sex, age group, and geographical place underline the value of preventative measures and boosting adolescent-responsive health care delivery systems, which should give special attention to needs by sex, age, as well as location [1]. Humans can spread the majority of infectious diseases through intimate contact. Therefore, both local and global human mobility have a significant role in the emergence and spread of epidemics [21]. He mentioned that access to extensive human mobility data is made possible by recent developments in information technology, IT, and the widespread use of digital sensors [21]. Enhancing wearable device that is capable of carrying out mini medical diagnosis to obtain patient's data will improve health care and physician's decision making, necessitate this study.

The purpose of this study is majorly to develop a web application dashboard that is capable of serving as a diagnostic assistant tool for medical practitioners, which is mostly useful either in emergency situations where the patient in question is incapacitated to respond to the questions of the medical practitioner or in situations where there is a communicable disease like covid-19 and it is also important to monitor the heart rate of the patient through the dashboard without the medical practitioner needing to move close to the patient.

The act of leveraging a dashboard to visualize the patient's data has helped to proffer solutions to some problems identified with the HIS. These problems include the integration of technology into clinical workflow and the ability to focus on a fragment of information needed actress system [2].

[2] evaluated the usability of a dashboard with the capability to visualize patient's data in order to make key information about patients enhance homecare. They developed a dashboard for visualizing electronic data where R-package was utilized alongside with R/Shiny web architecture. Also, they focused on visualizing health management tasks or fitness exercise and to monitor real-time acuity risk.

The remaining of sections are arranged as follows – section 2 (related work), section 3 (method), section 4 (result), and section 5 (conclusion).

II. Related Work

One of the ways of tracking clinical situation of patients or individual likely to be living with any form of diseases, via graphical or numerical values is the dashboard. Dashboards for clinical diagnosis are being utilized more frequently to give physicians information about particular quality of care indicators in a visually appealing style in an effort to enhance decision-making and quality healthcare [7]. Various scholarly works have been carried out regarding tracking and monitoring medical conditions.

A. Clinical Dashboard

Dashboard often used to identifies and monitor patients' progression as well as response to treatment using visualization means. [7] carried out multi-factorial research, where numeracy as well as literacy of graph by medical practitioners (nurses) were adopted. Results of the study shows 88 percent of selected nurses are proficient in the use of bar charts; 81 percent, 77 percent and 41 percent for tables, line graph and spider graph respectively [7]. They concluded that Clinical dashboards are utilized more frequently to present valuable information to clinicians in a visually appealing way with the theory that doing so will lessen their cognitive load. [10] carried out five user-centered app design sessions to accommodate the patients as well as their physicians in reviewing and attending to clinical challenges, which may result in safety inference. The study concluded that the application includes plain English "translations" of all clinical terminology used, links to carefully vetted patient educational resources, and simplified visuals to show changes in risk. Also patients need clarification of medical terminology as well as descriptions of variations in risk [10]. In systematic literature carried out by [11] outcome identified the impact of dashboard visualization as it provides solution that decreases amount of hours spent on information gathering. They concluded that prospective study can focuses on development and implementation of innovative, problem-solving dashboard. Moreover, [13] asserted that knowledge could be quickly accessed, and the dashboards were regarded to be client considerate and easy to understand. The dashboards were viewed well by the end users as a means of tracking respective learning adjustments. Additionally, the respondents thought dashboards might be used to track the effectiveness of changes to the unit's quality assurance approach (such as recording of the anesthesia technique) and the adherence to existing regulations [13].

[14] conducted an innovative concept for fitting in and offering health information adopting an extensive digital dashboard tagged "BESTBoard". They asserted that a novel idea for a healthcare dashboard technology turned out to be practical and helpful in providing medical personnel with healthcare data. For the intention of utilizing the technology, a good attitude and expectations for work productivity were crucial [14]. This discovery can help with the creation

of new methods for the efficient presentation of healthcare data.

The ability to retrieve pertinent, time-bond information from digital healthcare record and other computing infrastructure is essential for efforts to be monitored and manage hospital capacity [16]. However, the many ways in which patient flow is described, cohort decisions are made, subprocesses are involved, and there are several stakeholders that need data visibility, all of which add to the complexity. [16] created a digital dashboard for facilitating communication and utilize the Donabedian paradigm to order patient flow statistics. More so, the fusion of several technology innovation often opens up further possibilities for increased hospital capacity.

B. Application of Dashboard

Visualization of data/information using dashboard aid in finding trends or insight, which help in making apt discission driven by data. In the research conducted by [9], where they stressed on the essentialities of dashboard in tracking measurement of energy productivity. With more data available to companies globally, it is necessary to analyze, organize, and convey the knowledge gleaned from it [9]. When creating a target-oriented dashboard, the imagery and layout are quite important. As a result, visualizations including widgets [9];[15], graphs, and charts all need special consideration. Furthermore, energy-efficiency with the use of dashboard help with attempts to lower energy costs and, ultimately, lower emissions from greenhouse gas [4];[9]. On the other hand, the introduction of software solutions has had a significant impact on practically all aspects of human existence [5].

For the purpose of accurately understanding how students utilize a learning analytics solution, [12] developed a new dashboard layout called “MyLA” that is in line with SRL theory. Sequence analysis was done on the activities of 860 students across ten courses covering various fields using three distinct dashboard displays that were installed in an LMS. The study showed distinct dashboard usage patterns for students with varying levels of academic success and identity learning, notably for low achievers and strong self-regulators. From the study they stresses the significance of variations in students' experiences with a "student-facing dashboard" and emphasize that learning analytics tool design is not a one-size-fits-all endeavor [12].

The dashboard included motivating methods (such as comparison processes and entertainment), provided instructional materials, and allowed for encrypted chat. Graphics were utilized to display and highlight healthcare information and reinforce knowledge [17]. The final prototype allowed over 80% of participants to finish all 5 activities successfully. Improvements were made when usability issues with the design, use efficiency, content, and language were disclosed by interviews [17]. The framework to examine and create dashboard prototypes for SMEs businesses was established by [18], based on the findings, the SMEs may use dashboards to lower costs, conserve time, as well as improve their decisions. With the establishment of dashboard templates, SMEs may either construct a new dashboard by choosing only the charts and graphs they desire from the presets, or they can apply the templates explicitly by entering their data. Users don't need to be experts in data computation or dashboard creation as a result [18].

C. Appraisal

The assertion made from various existing literature reviewed has identified the essentiality attached with application of visualization dashboard for monitoring progress of healthcare challenges. The benefits of using dashboard tools comes in handy so sectors, which include academics (such as measuring and monitoring academic progress of students), financial sector (for business monitoring as well as giving report), sport (such as analyzing games), healthcare sectors, and so on.

[19], stressed on how valuable dashboard could be, in monitoring levels of various public health issues and afterward making an appropriate decision process. This forms the basis of this study.

III. METHOD

This section presents the materials and methods adopted in this study. This follows ED-Ear architecture Figure 1 shows the work flow of the system (system architecture). These include collection and exploration of data, preprocessing of data (cleaning and separation), auto scaling (service creation, API integration and data indexing), querying the data to meet user’s request and visualization of the output.

ED Architecture

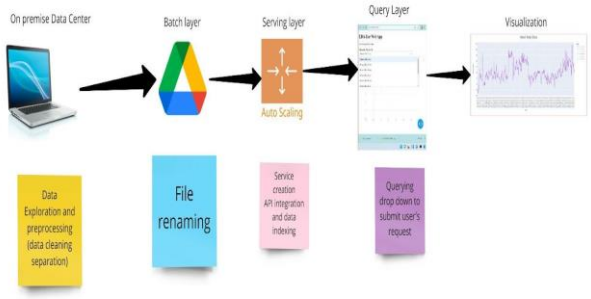

Figure 1: Electronic Dashboard System Work Flow

A. Data Collection and Exploration

The raw data were collected from a primary source (Wearable and Biosensing Lab). It is made up of records from wearable devices (Apple wrist watch devices); and the datasets were obtained in batches. The collected datasets form various version of batches (15 batches). They have varieties of features or attributes of patients depending on the data sets collected using the device, which necessitate exploration of the collected datasets to refine them.

Having collected the data unorganized or unstructured, the data is explored to analyze, uncovered the basic patterns as well as possible

characteristics of the datasets. This process includes preprocessing – cleaning and separating or arrangement of the data accordingly.

B. Preprocessing

After collection of data and its exploration, the datasets were preprocessed. This begins with the cleaning of the data, by removing (dropping) incomplete tuple while duplicate and redundant attributes were corrected in the data. However, there were instances of wrong data which were corrected based on the discovered characteristics during the data exploration. Examples are as stated below.

Solving the issue of the wrong data discovered: There are different methods of solving issues that relate to wrong data. This includes: dropping the data, replacing the data with either mean, median or mode. The method adopted in solving this problem was to first examine the wrong data, compare it with other similar data then decide on the appropriate method to mitigate the problem in each case.

Data with Patient ID '030': '030' is a string but when converted to an integer would give 30. Hence, it is logical to examine patient number 30 and '030' when trying to solve this issue. One can logically assume that the entries for patient ID 30 were entered as '030'. In the same vein, if we consider the number of entries for patient '030' with respect to that of patient 30, It is so large as shown in Figure 1 and dropping the data would end up making us lose some useful information for patient 30. Therefore, the data for 030 was adopted as 30 by converting it to integer.

```
In [16]: patient_Wrong_Data3 = acc[acc['Patient.ID'] == '030']# to index the data frame to access the data of patient '030'
         print(patient_Wrong_Data3)

         Patient.ID      Date        Time X.Acceleration..m.s.s. \
1703936        030  09/01/2017  19:32:24.400             -1.426025
1703937        030  09/01/2017  19:32:24.517              4.071533
1703938        030  09/01/2017  19:32:24.636              4.056152
1703939        030  09/01/2017  19:32:24.765              0.142822
1703940        030  09/01/2017  19:32:24.996              1.812744
...            ...         ...         ...                   ...
1835003        030  09/02/2017  18:22:42.736             -2.913574
1835004        030  09/02/2017  18:22:42.869             -2.333496
1835005        030  09/02/2017  18:22:42.986             -2.449951
1835006        030  09/02/2017  18:22:43.116             -2.724609
1835007        030  09/02/2017  18:22:43.236             -2.320312

         Y.Acceleration..m.s.s. Z.Acceleration..m.s.s.
1703936               2.195068               4.860352
1703937               5.589844               7.046631
1703938               9.021973               5.174561
1703939               7.611328               4.051758
1703940               9.358154               3.972656
...                        ...                    ...
1835003               7.371826               4.398926
1835004               8.347412               3.065186
1835005               7.921143               3.227783
1835006               8.518799               2.950928
1835007               8.013428               3.487061

[131071 rows x 6 columns]
```

Figure 2: An overview of the data for patient '030'

Data with Patient ID 'Patient ID': The illustration in figure 2 reveals that there is no useful information that could be obtained from this data. Therefore, Also, the data is just two entries and dropping it will have little or no effect on the entire data. As a result of this, the data was dropped.

```
In [11]: patient_Wrong_Data1 = acc[acc['Patient.ID'] == "Patient ID"]# to index the data frame to access the data of 'Patient

In [13]: print(patient_Wrong_Data1)

         Patient.ID  Date  Time  X.Acceleration..m.s.s. \
7032428  Patient ID  Date  Time  X-Acceleration (m/s*s)
980631   Patient ID  Date  Time  X-Acceleration (m/s*s)

         Y.Acceleration..m.s.s.  Z.Acceleration..m.s.s.
7032428  Y-Acceleration (m/s*s)  Z-Acceleration (m/s*s)
980631   Y-Acceleration (m/s*s)  Z-Acceleration (m/s*s)
```

Figure 3: Data with patient 'Patient ID'

Data with Patient ID '09/02/2017': This data is just one entry and dropping it will not have much effect on the entire data.

```
In [15]: patient_Wrong_Data2 = acc[acc['Patient.ID'] == '09/02/2017']# to index the data frame to access the data of patient'
         print(patient_Wrong_Data2)

         Patient.ID        Date      Time X.Acceleration..m.s.s. \
1743268 09/02/2017 11:39:40.259 4.6955566              6.240234

         Y.Acceleration..m.s.s. Z.Acceleration..m.s.s.
1743268               4.464844                    NaN
```

Figure 4: Data with patient '09/02/2017'

Finally, the data were separated and arranged into new batched based on each patient. This gave a total of 116 batches. Each data set was majorly in three categories – patient's Accelerometer (ACC) data, patient's contact data and patient's heart rate (HR) data. The purpose of the research was to access the raw data sets via the dashboard; therefore, data transformation was not performed on the data.

C. Database

After the data exploration and preprocessing on premise, the dataset batches were uploaded to the data base (google drive). Renaming of these data sets were done to ensure uniformity among each data set. Service was created and the data base was interfaced with the google application programming interface (API) to enable communication between the data base and the querying layer. data indexing was carried out from database. This is to perform absolute optimization performance of the database and for easy retrieval of the information. Auto scaling on the datasets was done to ensure any of the data set of interest could be accessed on the web app.

IV. Result and Discusion

This section the result and discussion of data collection and exploration. From the data exploration conducted, a group of 15 data sets which were categorized into three were obtained. Based on the categories of the data sets obtained, the data sets were combined to give a total of 116 unique data sets. The data sets were divided into three categories of 116 each. The categories represent the type of dataset collected. The three categories of datasets

collected are; the heart rate (HR) data, the contact data and the accelerometer data (Acc).

A. Data Characteristics

Table 1: Data Characteristics

Data Features	Acc	Contact	HR
Common Columns	Patient ID Date Time	Patient ID Date Time	Patient ID Date Time
Different Columns	X.Acceleration.. m.s.s. Y.Acceleration.. m.s.s. Z.Acceleration.. m.s.s.	Contact.State	Quality (Acquiring or locked)
Variable Classification for different columns	Continuous	Categorical	Continuous
Number of Files	15	15	15
Data size	11.21GB	9.5MB	1.21GB
Number of Patients	116	116	116

Table 1 shows the major characterization and categorization of the dataset. This is based on the following common columns in individual datasets (such as patient ID, date and time patient's information were collected), different columns and their variable classification, number of files, data size and number of patients records were taken (116).
Each category was assigned to a dropdown and from the dropdown, the graphical representation of the data was displayed whenever the dropdown was selected.

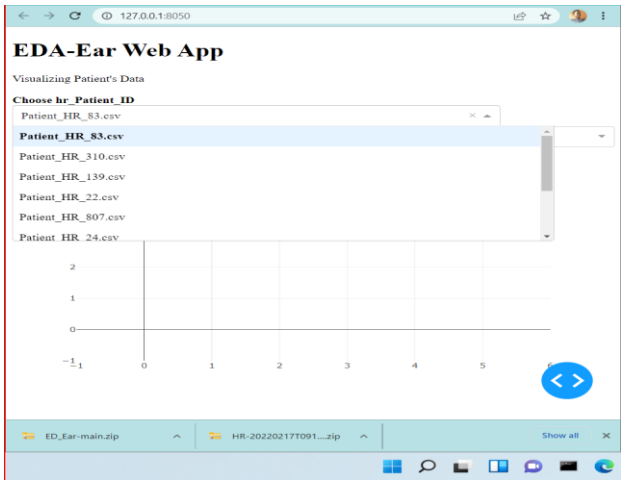

Figure 5: ED web app interface

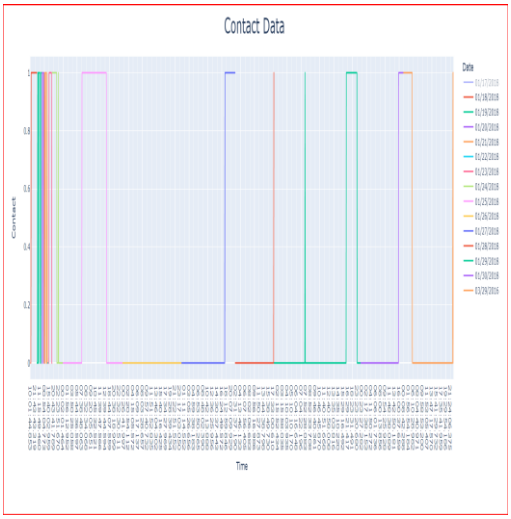

Figure 6: Web page visualizing the patient's contact data for the date that was greyed out

Figure 6 represent the system interface on web page. As certain information is selected the pattern or trends of the information is visualized under as displayed in figure 6.

Dashboard visualization
Figure 7: Heart rate of patient 941 on 07/12/2017

Dashboard is a visualization and data analysis tools that provides insight on hidden pattern or trends present in a certain dataset. Figure 5B shows the heart beat rate of certain patient with respect to date and time the records were taking. ED is an essential web app which could aid health practitioners to make appropriate data driven decisions.

CONCLUSION

This study focused on development of web app that enhances the emergency health record dashboard for visualization of patient's health records based on their historical datasets collected from wearables. The system is to enhance electronic health record (EHR) and provide physician rapid means of getting health related information of an individual patient. Based on the result, ED-Ear system could visualize health records of patients by providing all relevant information and hidden patterns in the raw data set. The system is able to show graphical representation of health-related record such as patient's heart rate and acceleration which could determine the adherence of a patient to physical therapy through the accelerometer data. The clinical diagnosis or monitoring information could be determined from these graphs. More datasets could be collected and deployed into app for further studies to better improve the study.

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