Image Based Height & Weight Calculation and Data Visualization for the Public Health Monitoring System of Filipino Children

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ABSTRACT
The research focuses on the development of additional features of the Embodied Conversational Agent (ECA) System which is used as an aid in public health monitoring of Filipino Children. The ECA system prior to this research accommodates both health monitoring and consultation activities for Filipino children. This research aims to provide a platform for medical professionals and government authorities to view an aggregated or specific health transcript of Filipino children and provide an alternative way of measuring height and weight via image processing. The platform for viewing the data collected by the prior ECA system is a mobile application whose purpose is to show the results of the monitoring and consultation activities as raw data or as a data visualization. The data visualization implemented can accommodate both aggregated results of patients or individual results over time. The alternative way of measuring height and weight via image processing is integrated to the previous system and returns the calculated height in centimeters and weight in kilograms. The research, including the improved system, is part of the GetBetter Telemedicine System.

Keywords
Visualization, Image Processing, Health Informatics, Cloud Computing

1. INTRODUCTION
World Health Organization (WHO) found potential in information communications technology (ICT) to advance telemedicine due to its popularity and integration in day-to-day activities in present society. Telemedicine is a healthcare delivery concept which enables patients living in locations distant from health centers especially in rural areas gain access to healthcare through the use of telecommunication technologies [1].

Several telemedicine schemes have already been deployed and applied in the Philippines. One of them is the GetBetter System which allows doctors offsite to reach marginalized communities by giving instruction to nurses onsite through the use of ICT [2]. Under this system lies the Embodied Conversational Agent (ECA) System for Public Health Monitoring of Filipino Children developed by Lacsamana et al. (2016) [3]. It is a mobile application named GeeBee that is developed for android tablets which supports both monitoring and consultation activities.

The health monitoring module under GeeBee records the height and weight of the patient but are loaded only through textual input. Therefore, the height and weight is measured using the external tools such as a stadiometer, weighing scale, height ruler or other measuring tools. An existing alternative way to measure the height and weight of a person without measuring tools is through the use of image processing.

GeeBee can only collect and store the results of the monitoring and consultation activities without ever displaying it. Simple collection of the health information of children is not enough to bring attention the various health problems encountered by children. With the help of data visualization, medical practitioners and authorities alike are able to view the collected data to monitor the health and growth of the children.

GeeBee prior to the research can only store the collected data in a local database. This limits the access to the data since it is only stored in the tablet itself. By applying cloud computing to GeeBee, the data collected can be uploaded to a remote database and downloaded when needed to be accessed [4].

2. REVIEW OF RELATED LITERATURE
2.1. Review of Related Studies
Telemedicine supports medical services through the use of telecommunications. Telecommunications used in medical applications can be defined as sending medical information between a pair of transmitters and receivers. A simple modern example of telemedicine is a real-time online video consultation of a patient to a doctor.

Data visualization is a way to see or visualize a summarized data that is gathered by the system. There are many different types of data visualization that are being used nowadays. However, selecting the right type of visualization is not an easy task because each type of visualization has its own benefits and downfalls because each chart emphasizes and excludes certain types of information such as changes over time, differences between two sets, contribution to a whole and etcetera. Data Visualization is beneficial in a way that it should make the collected data more meaningful and comprehensive even to non-professionals who have a hard time in interpreting the data which is out of their specialized field [5].

One approach for taking the height measurement is using Smart Measure. It is an App developed by Smart Tools Co. that

calculates the distance and height of the target using trigonometry [6].

Another approach is the study of Criminisi (1999) using a CCTV in order to determine the height. The algorithm used to compute the height is based on projective geometry. The study mentioned that one can compute by using a reference height. The reference object serves as a constant to address the perspective difference. To calculate the height, the height of the reference object is used; this reference height is the length of both the top and base points in a vertical direction [7].

2.2. Review of Related Software

The GetBetter System is a telemedicine system that allows the tele-presence of medical doctors to assist nurses in remote and marginalized communities [2]. It is funded by the World Health Organization–-Tropical Diseases Research (WHO-TDR) in Geneva. The first version of the GetBetter System is a cloud-based web-service designed based on the latest internet web-access protocols at that time. Since then, the system has been enhanced by the addition of an offline version unhooked to the internet using android-based tablets that integrate seamlessly with the online subsystem of GetBetter even under conditions of difficult and intermittent internet access.

3. IMPROVEMENT OF THE PUBLIC HEALTH MONITORING SYSTEM OF FILIPINO CHILDREN

Under the GetBetter Telemedicine System in the Philippines lies the Embodied Conversational Agent System which focuses on public health monitoring of Filipino children (Lacsamana et al., 2016). It aims to fulfill the need for children to undergo routine wellness checks with a doctor in communities that may not have accessible, affordable, or quality health care. In this subsystem, prior to this research there already exists a data gathering software entitled GeeBee.

Under the health monitoring module lies a Body Mass Index (BMI) test which requires the numerical input of the height and weight of children however it cannot be performed without the use of measuring tools. In response, this research developed an alternative way for the collection of the height and weight. By utilizing the built-in camera of the tablet, GeeBeeCapture calculates the height and weight through image processing and returns the calculated values to GeeBee. The calculated height and weight may not be exact however the approximate will be enough to determine the BMI of the patient.

GeeBeeView is a mobile application developed to display the data collected by GeeBee from the previous research. It allows both medical professionals, authorities, and researchers to view both the health conditions of children over time and charts of aggregated health conditions of children with a demographic of school and creation of record. Cloud computing was applied to both GeeBee and GeeBeeView so that there will be a one-way sharing of data. GeeBee collects data offline; however, if there is an internet connection, the user can choose to upload the recorded data to the cloud directory. GeeBeeView downloads the recorded data from the cloud directory and displays it. GeeBeeView was developed to work offline but requires data that has to be downloaded from the cloud directory.

Sharing of data between GeeBee and GeeBeeView will only be done through the use of uploading and downloading from the cloud. The purpose of GeeBeeView is to show the downloaded data to the doctors or medical experts who are not physically present in the rural areas. In this way, doctors are able to check on patients and know the status of their health even if they are remotely far from each other. It is not required that both applications have internet connection all the time. Internet connection is only required for uploading and downloading purposes.

3.1 System Architecture

The improved Public Health Monitoring System consists of four major components: the data collection application (GeeBee), the data visualization application (GeeBeeView), the image processing application (GeeBeeCapture) and the cloud hosted database. The GeeBee application already existed prior to this research developed by Lacsamana et al. (2016). Some minor improvements were done to it wherein one is connecting its local database to the cloud for uploading while accessing the other applications from it is another. The GeeBeeView application was created in this research consists of the data visualization module while also being connected to the cloud database for downloading. The image processing software developed to calculate height and weight using image processing as an alternative for manual measuring. The cloud hosted database is nothing more than a storage space in the cloud so that sharing data is more efficient.

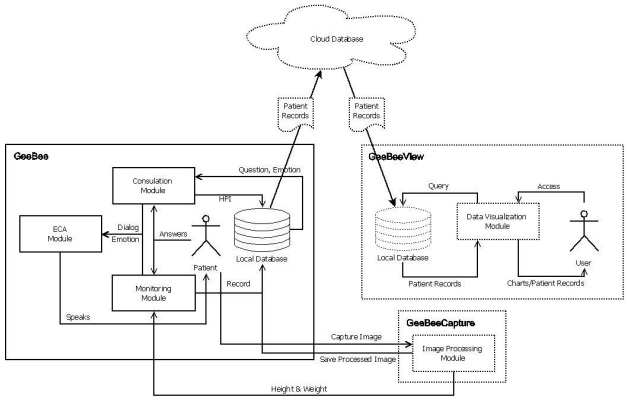

Figure 3.1 System Architecture

3.1.1 GeeBee

Though GeeBee has been connected to the cloud database and has a few added functionalities, it still retains the its previous system architecture. It has three existing modules namely the ECA module, the consultation module, and monitoring module. Please refer to the document of Lacsamana et al. for elaboration.

3.1.2 GeeBeeView

The data visualization application, GeeBeeView, is a mobile application developed to be functional without internet connection thus it contains a local database from where it queries data to be charted. Its local database can be connected to

the cloud database to download patient records and related data which it can display. It has two major data visualization functions which are to visualize aggregated health conditions of patients and to visualize the health condition change over time of a single patient. The visualization for both functionalities were charted using MPAndroidChart which is an outsourced API developed by Philipp Jahoda.

3.1.3 GeeBeeCapture

GeeBeeCapture takes images and computes for the height and weight of the child with a ruler as the reference object. The module uses OpenCV for implementation. It is a standalone application and is separate from the GeeBee application. It is connected to the camera of the device and receives two images as its input: one image in the front view, and the other in the side view. It converts the images as a silhouette first. Afterwards, it computes an estimated height and weight as a numerical value which will be passed as an input to the Monitoring Module without changing the process flow.

The height is calculated using the front view of the child. The pixels per metric ratio describes the number of pixels that can "fit" into a given number real world measurements such as inches, millimeters, and meters. This can be computed by using a reference object, in this case, a ruler which has a measurement of 30.48 cm. The ruler must also be easy to find for it to work.

$$pixelsPerMetric = objectPixelHeight/knownHeight$$

The person's height is calculated using the subjectHeight formula. The topPoint is assumed to be the top most contour which is the person's head. The bottonPoint is the bottom most contour which is assumed to be the point where the wall and ground intersects.

$$subjectHeight = (topPoint - bottomPoint)/pixelsPerMetric$$

For this research, a data collection for the height and weight with the image of 30 children was conducted. Data Analysis was performed twice, one using the front width, side width and actual height while the other using front width, side width and computed height to get these two equations. Equation 1 is based from the actual height while Equation 2 is based from calculated height.

Equation 1:

$$weight = front_{width} \times -0.4556 + side_{width} \times 0.0728 + height \times 0.3102$$

Equation 2:

$$weight = front_{width} \times -0.306 + side_{width} \times 0.0721 + height \times 0.2606$$

3.1.4 Cloud Database

The cloud database allows the storage and retrieval of the data gathered for this system into a cloud database serving as a repository wherein the different applications that are part of the system can access the data. It will by no means alter or change the data itself. The cloud database is connected to both the GeeBee and GeeBeeView applications. The cloud computing module for GeeBee uses only a straightforward process of uploading the data in the local database to the cloud database at the press of a simple press of a button where the data from the local database is evaluated and checked if it was already uploaded to the main remote cloud database. The consultation and monitoring module is not modified from the original GeeBee application and is still connected to the local database which enables the application to still work offline. The data from the local database will only be uploaded to cloud whenever the tablet is connected to the Internet with the user's consent. The cloud computing module for GeeBeeView allows access to the cloud repository and manually choose the dataset which it will download and copy to its local database at the start of the application workflow. The data visualization is connected to the local database and only visualizes data from its local copy allowing it to work offline but it requires the user to download the dataset first before it will be able to visualize any data.

3.2 System Functions

3.2.1 GeeBee

The original GeeBee already had functionalities prior to this research which are divided in six (6) major functions namely the ECA, the user list, activity selection, monitoring module, consultation module, and application settings. The ECA possessing the ability for both verbal and nonverbal communication. The addition and selection of a patient. The activity selection wherein the user can branch to either the monitoring or consultation module. The monitoring module containing six (6) submodules for routine check-up specifically general monitoring, visual acuity test, color vision test, hearing test, gross motor test, and fine motor test. The consultation module containing the expert system and HPI generation. Finally, the application settings where calibration and other details are set.

The newly developed functions in GeeBee are only limited to data handling going to the remote cloud database. The selection, addition and removal of schools from the local database is also a part of the newly added functionalities so that in order to determine what school the user is currently recording data for. The main function added to the GeeBee Application in lieu of databases is the feature to sync data to the remote cloud database seamlessly with just a press of a button.

3.2.1.1 School Selection

School selection from the previous version of the GeeBee was only limited to a defined set of schools that the user cannot add or remove. With the new modified functionalities, it is now possible to not just select schools but also to add and remove schools to be used for the consultation and records. Adding these features is relevant to this research as this would add modularity and aid in streamlining the process of consultation using the application. The user would not have to request to add new schools from database managers.

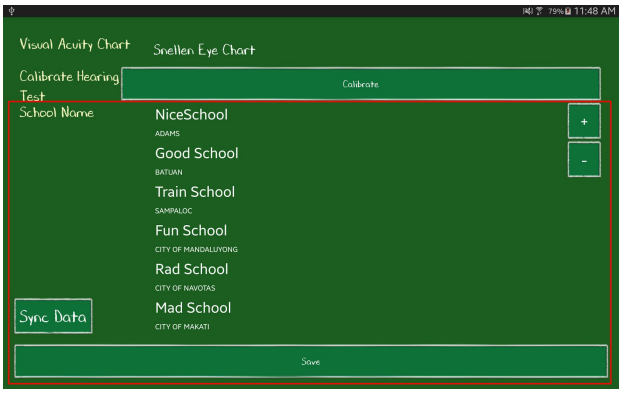

Figure 3.2 School Selection

3.2.1.2 Uploading/Syncing Data

The ability for the GeeBee application to upload and synchronize with the remote database is one of the main objectives of this study. Before, all data collected by the application all resided in the particular devices local storage and has no way of getting to the remote database. Now, with just a button, the user can leave the device to upload all the data all by itself.

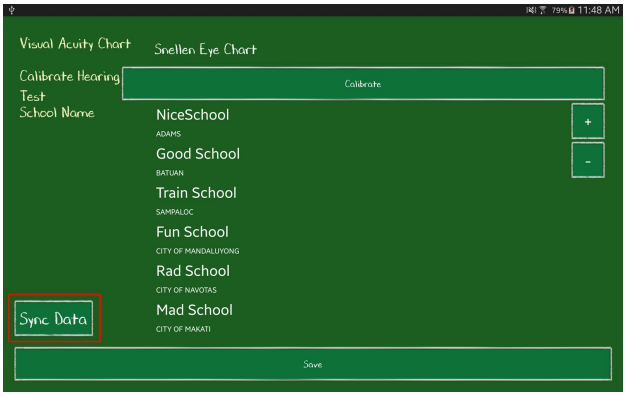

Figure 3.3 Sync Data

3.2.2 GeeBeeView

GeeBeeView is a mobile application for displaying collected data of GeeBee. Its functions are mostly about the display of data and does not insert to the database except for the user authentication.

3.2.2.1 Authentication

Before the software enables the user to be able to view data from the software, the user must be first authenticated with a valid GeeBee account. Even if the user can sign up in this screen, the system manager must first authorize access.

Figure 3.4 Authentication

3.2.2.2 Dataset List

After authentication, the user will be shown a dataset list. Each dataset pertains to a collection of data from patients which are grouped based on which school they belong to and the date wherein their record was created. The datasets must be downloaded from the cloud database first and copied to the local database. Once copied, the dataset is ready for viewing.

Figure 3.5 Dataset List

3.2.2.3 Data Visualization of Aggregated Results

After the user selected a dataset for viewing, a data visualization of the aggregated health condition of the group of patients is generated. The default chart generated is a pie chart of the BMI classification of the patients. From here, it is possible for the user to view the consultation list or patient list.

The visualization displayed is interactive and adjusts based on the selected source dataset/s, filter/s, chart, comparison set, and result of a health test. From the visualization of only one dataset, it can added on with another dataset with no limit. These additional datasets may be removed until only the original one is left. The contents of the datasets may also be filtered according to age and gender which can be added and removed. The chart may also be changed from the default pie chart to either a bar, scatter, or bubble chart. The health test result viewed may also be changed from the default BMI classification to visual acuity (left or right), color vision, hearing (left or right), gross motor, and fine motor (dominant, non-dominant, and hold). The comparison set is only available if the chart type is either pie or bar. It allows comparison of the dataset/s in the dataset list with

a larger set which can be either the national profile, region, province, or municipality wherein the initial dataset resides in.

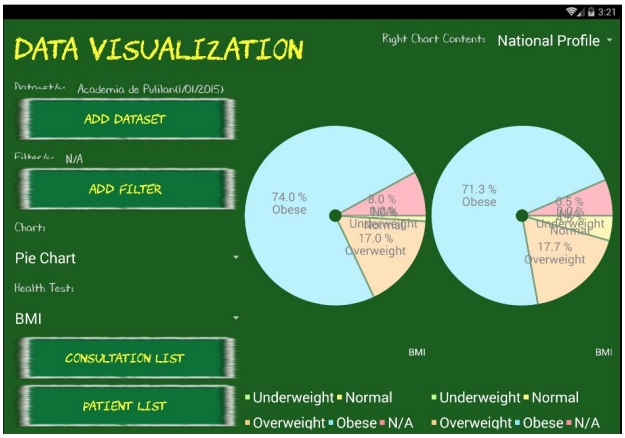

Figure 3.6 Data Visualization of Aggregated Results

3.2.2.4 Consultation List

The consultation list is a list of consultations recorded from the consultation module in GeeBee. This list contains all the consultations recorded from only one school which was originally selected in the data visualization of aggregated patients. It displays the name and date of consultation.

Figure 3.7 Consultation List

3.2.2.5 Consultation Record

To view a consultation, the user can click the view button from the consultation list. It will display the generated HPI of a patient detailing the symptoms experienced.

Figure 3.8 Consultation Record

3.2.2.6 Patient List

The patient list is a list of patients who went through the general monitoring module which are included in the specified dataset. This patient list is arranged in chronological order displaying the name, gender and age of the patient when the record was created.

Figure 3.9 Patient List

3.2.2.7 Transcript of Health

To view patient information, click the view record button next to the age of the patient whose record will be displayed. Patient information includes the patient details, record details, and visualization on change over time of health condition. The patient details include the name, birthday, gender, dominant hand, last checkup date, remarks, and patient picture. The record details refer to check-up results which includes the height, weight, visual acuity of left and right eye, color vision, hearing of left and right ear, gross motor, fine motor of dominant and nondominant hand, and remarks. The default record details displayed is on the latest dated record but can be swapped with previous records using the drop-down menu located above the record details.

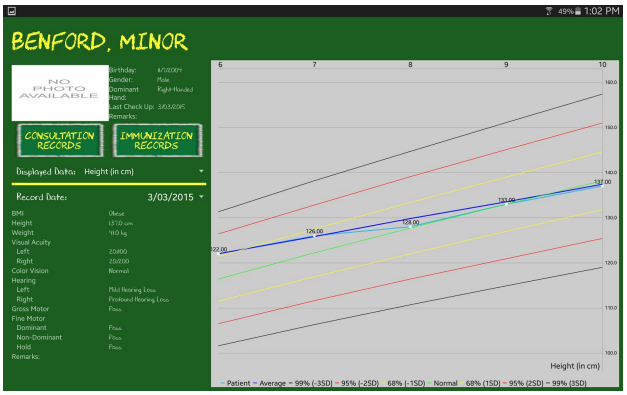

Figure 3.10 Transcript of Health

3.2.2.8 Immunization Record

The immunization record can be viewed by clicking the view immunization record button from the view patient screen. The immunization record to be viewed by default is the latest one however it is possible to switch out with previous records by using the dropdown option on the upper right of the screen.

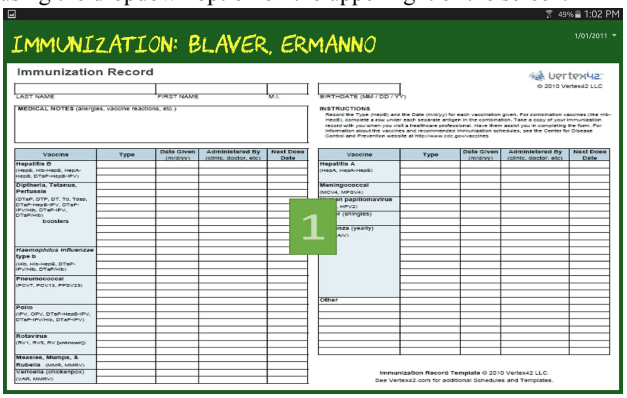

Figure 3.11 Immunization Record

3.2.3 GeeBeeCapture

GeeBeeCapture is a mobile application that is integrated to GeeBee as an alternative way to measure the height and weight of children. It calculates the height and weight by image conversion and retention then image computation.

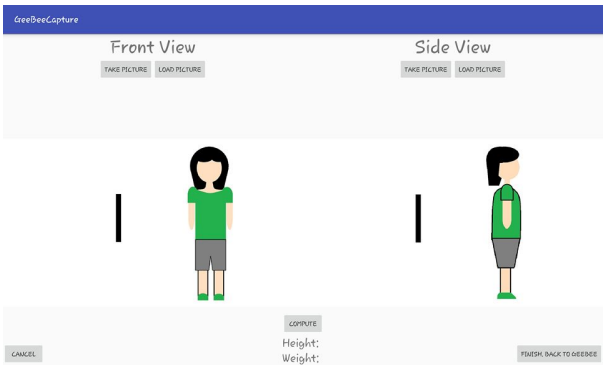

Figure 3.12 Starting Screen

3.2.3.1 Image Calibration

The Image Calibration function will be responsible in removing the background of the image in order to retain only the subject and the reference object to be calculated in the other function.

3.2.3.2 Image Conversion and Retention

The Image Conversion function turns the original image into a silhouette that is saved into the system and also reprocesses the image to be used for calculation.

3.2.3.3 Image Computation

The Image Computation function computes for the height and weight of the child and then categorizes the weight group. The calculated data is passed to the Monitoring Module of GeeBee.

Figure 3.13 After Calculation

4. RESULTS AND OBSERVATION

The entire system was tested as per the requirements defined by the objectives of the research. The tests performed were based on the overall requirements and functionality of the system.

4.1.1 School Selection

School selection should allow the user to add, delete and select a school to use for their current session.

Test Case #	Test Description	Test Steps	Expected Output	Actual Output
1	Add School from Settings	From the main screen, open settings by pressing gear button on the upper right corner, tap plus (+) button and fill up details. Then tap "Add".	Addition of school is confirmed via toast message.	Toast message shows "School Added"

2	Remove School from List	From settings, select a school to remove, tap minus (-) button.	Selected school will be removed from list with toast feedback.	Toast message shows "School Removed"
3	Select School from school list.	From settings, select a school to use, then press save button at the bottom.	Toast will confirm selection and school will be saved.	Toast shows "SCHOOL -NAME-HERE Selected"

4.1.2 Uploading / Sync

After performing the monitoring and consultation activities, it is vital to upload the data collected for viewing because GeeBee by itself does not have any functions for displaying the data collected.

Test Case #	Test Description	Test Steps	Expected Output	Actual Output
4	Sync / Upload to remote database with Internet connection.	From the main screen, tap "Let's go" and then tap "Sync Data" near the bottom right.	Uploading data is confirmed via toast message.	Toast message states "Data Synced"
5	Sync / Upload to remote database without Internet connection.	From the main screen, tap "Let's go" and then tap "Sync Data" near the bottom right.	Uploading data fails.	Toast message states "No Internet Connection"

4.2.1 Authentication

The function allows users to signup and login to gain access to the patient information that the application will display. It also serves as a security defense so that all users must first have a username and password.

Test Case #	Test Description	Test Steps	Expected Output	Actual Output
6	Sign Up	Fill up the username and password textbox, then press the “sign up” button.	The registration is confirmed via toast message.	Entered “qwerty" as username and “uiop" as password. Confirmed success by toast message.
7	Login	Fill up the username and password textbox, then press the “login" button.	The dataset list is displayed.	Entered “qwerty" as username and “uiop" as password. Dataset list is displayed.

4.2.2 Dataset List

The dataset list allows users to refresh the list and view or download a dataset. This is the next view after the successful login. As default, the application tries to download the latest dataset list from the cloud database however if there is no internet connection, the list will come from the local database. The dataset list will display the school name, date created, and an action button. If the dataset has not yet been downloaded, the text on the button will be “download" and otherwise “view."

Test Case #	Test Description	Test Steps	Expected Output	Actual Output
8	Refresh List	Click the “refresh" button.	The dataset list displayed will be updated to the latest one.	Dataset list was updated.
9	Download Dataset	Click the “download " button of the selected dataset.	The dataset will be downloaded and the action button text will change to “view."	Click the “download " button of the dataset “Knights and Angels Montessori School" on “05-05-2015." It downloads then after downloading the button text changed to “view."

10	View Dataset	Click the “view" button of the selected dataset.	The data visualization activity is started and contents of the selected dataset is visualized.	Click the “view" button of the dataset “Knights and Angels Montessori School" on “05-05-2011." The data visualization activity started.

4.2.3 Data Visualization for Aggregated Results

The data visualization for aggregated results allows the user to have an interactive visualization of the aggregated health test results of patients whose monitoring records are part of the the dataset/s loaded to be visualized. The default chart is a pie chart displaying the distribution of the patients into different BMI categories.

Test Case #	Test Description	Test Steps	Expected Output	Actual Output
11	Add Dataset	Click the “Add Dataset" button. Select a dataset from the dropdown menu that will appear in a dialog. Click the “Add" button in the dialog.	The dataset selected will be added to the dataset list on the upper left corner and the visualization will be refreshed To accommodate the additional data.	Added the dataset for “Academia de Pulian" on “01-01-2011." The dataset was added to the dataset list and the chart adjusted.
12	Remove Dataset	Click on the “X" next to the dataset to be removed.	Both the dataset list and visualization should reflect the removal of the dataset.	Removed the dataset for “Academia de Pulian" on “01-01-2011." The dataset was removed from the dataset list and the chart adjusted.
13	Add Filter	Click the “Add Filter" button to open the filter dialog. To add age filter, select an equator from the dropdown menu, then fill the textbox next to it. To add gender filter, select a gender from the dropdown. Click the “Add" button on the filter dialog.	The filter list below the dataset list should show the filter/s added and the visualization will refresh to accommodate the filter.	Added filters, \age < 6" and “gender = Male." The filters were added to the filter list and the chart adjusted.
14	Remove Filter	Click on the “X" next to the filter to be removed.	The filter list and the visualization should reflect the removal of the filter.	Removed filter “gender = Male." The filter was removed from filter list and the chart adjusted.
15	Change Chart Type	Select a chart type from the dropdown next to the “Chart Type:" label.	The visualization should change to the chart selected retaining the health test.	Selected the chart type “Bar Chart." The pie chart became a bar chart.
16	Change Displayed Data	Select a health test from the drop down next to the “Displayed	The visualization should change to the health test	Selected the test “Hearing Right." The chart reflected

		Data:" label.	selected retaining the chart type.	the change.
17	Change Comparison Set	Select a compariso n set to be compared with the set listed in the dataset list.	The visualized compariso n set should change according to the selected larger set.	The default compariso n set is "National Profile." Select the "Province" from the dropdown menu from the upper right corner of the screen. The visualizati on reflected the change.
18	View Consultatio n List	Click the ‘View Consultati on List" button.	The consultatio n list should be displayed.	Consultati on list consisting of “Blaver, Ermanno" on “12-04-20 17" and “Claffey, Tadd" on “10-13-20 17" was displayed. Both Consultati on records belong to the selected school.
19	View Patient List	Click the “View Patient List" button.	All the patients whose data is visualized should be listed.	Only the patients from the initial dataset were listed.

4.2.4 Consultation

The consultation list allows the user to view the list of consultation records related to the dataset selected. The consultation list displays the patient name, the consultation date and a view button.

Test Case #	Test Description	Test Steps	Expected Output	Actual Output
20	View Consultatio n	Click the “view" button of the selected consultatio n record.	The name and consultatio n details should be displayed.	Selected the consultatio n record of “Blaver, Ermanno" on “12-04-20 17." The name and consultatio n details were displayed.
21	View Other Consultatio ns of Same Patient	On the up-per right of consultatio n activity, select a consultatio n date.	The consultatio n details on the date selected should be displayed.	Selected the date “12-01-20 16." The consultatio n details were replaced with the consultatio n recorded on that date.

4.2.5 Transcript of Health

The transcript of health function allows the user to view various records of the student. The information shown can be divided into three parts namely the patient details, record details, and visualization. The default visualization is a line chart depicting the height of the patient over time.

Test Case #	Test Description	Test Steps	Expected Output	Actual Output
22	View Patient	Click the “view" button of the selected patient.	Patient informatio n and other details should be displayed.	Clicked the “view" button of “Bethel, Siuox." The patient informatio n was displayed.
23	Change Displayed Data	Select a health test from the drop down next to the “Displayed	The visualizati on should change to the health test	Selected the test for “Weight." The chart reflected the change.

		Data:" label.	selected.	
24	Swap Patient Record Displayed	Select a record date from the dropdown next to the “Record Date:" label.	The record details displayed should be updated and correspond to the record details collected on the date selected.	Selected the record date “01-01-2011." The record displayed reflected the change.
25	View Con-sultation List	Click the “View Consultati on" button.	The latest consultatio n details of the patient should be displayed.	The consultatio n on “12-04-2017" of the patient was displayed. It was the latest one.
26	View Immuniza-tion .	Click the “View Immunizat ion" button.	The latest immunizati on record of the patient should be displayed.	The immunizati on record on “01-01-20 11" was displayed. It was the earliest one.
27	Swap Immunizati on Record Displayed	Select a record date from the dropdown on the upper right corner of the screen.	The immunizati on record collected on that date should be displayed.	Selected the record date “01-01-2015." The immunizati on record displayed reflected the change.

6.3 GeeBeeCapture

The GeeBee capture module allows the user to be able to take the picture of the subject and determine the height and weight of the subject.

Test Case #	Test Description	Test Steps	Expected Output	Actual Output
28	Take Picture (Front View)	Click the “Take Picture" button on the left part of the screen. Take a picture with the camera. Select "Ok" after taking the picture.	The picture taken should be displayed in the Front View layout or left part of the screen.	The picture taken was displayed in the Front View layout or left part of the screen.
29	Take Picture (Side View)	Click the “Take Picture" button on the right part of the screen. Take a picture with the camera. Select "Ok" after taking the picture.	The picture taken should be displayed in the Side View layout or right part of the screen.	The picture taken was displayed in the Side View layout or right part of the screen.
30	Load Picture (Front View)	Click the “Load Picture" button on the left part of the screen. Choose a picture from the Gallery.	The picture selected should be displayed in the Front View layout or left part of the screen.	The loaded picture was displayed on the Front View layout or left part of the screen.
31	Load Picture (Side View)	Click the “Load Picture" button on the right part of the screen. Choose a picture from the Gallery.	The picture selected should be displayed in the Side View layout or right part of the screen.	The loaded picture was displayed on the Side View layout or right part of the screen.
32	Compute and Save	Click the “Compute and Save" button.	The height and weight of the child should be displayed	The height and weight is displayed below the

			below the "Compute and Save" button. The silhouette should be saved.	"Compute and Save" button.
33	Finish. Back to GeeBee Application	Click the “Finish. Back to GeeBee" button.	GeeBeeCapture should close and return the calculated height and weight to the GeeBee application	GeeBeeCapture closed and returned to the GeeBee application.
34	Cancel	Click the “Cancel" button.	GeeBeeCapture should close and return to the input of height in the GeeBee application	GeeBeeCapture closes and returns to the GeeBee application.

Four weights (Weight A, B, C and D) were calculated using the computed front width, computed side width and height. Weight A uses the first equation to get the predicted weight using true height. Weight B uses the first equation to get the predicted weight but using the computed height. Weight C uses the second equation to get the predicted weight using true height. Weight D uses the second equation to get the predicted weight but using the computed height. The following computations can be seen in Table 4. There are four errors computed (Error A, B, C and D). These four errors are their difference between the true weight and predicted weights A, B, C and D.

	RMSE	Total Accuracy	Standard Deviation
Height	1.48	98.88%	1.46
Weight A	2.37	92.26%	2.41
Weight B	2.43	91.20%	2.46
Weight C	2.41	92.01%	2.44
Weight D	2.35	92.05%	2.39

Table 4. Summarized Results of Height and Weight

5. CONCLUSION AND FURTHER WORK

The group was able to meet all the objectives in the research. The improved public health monitoring system on the research is now composed of three mobile applications. GeeBee for data collection. GeeBeeCapture for measuring height and weight via image processing. GeeBeeView for displaying the collected data and applying data visualization.

GeeBeeCapture is a standalone image processing mobile application that was designed to calculate the height and weight of children using their images as input. GeeBeeCapture can be accessed from GeeBee as an alternative way to measure height and weight without disrupting the process flow. The images of the children are not censored when taken; however, they are immediately disposed of for confidentiality and to prevent misuse.

The image processing module developed is not capable of computing the height and weight of children accurately without the use of external tools. The setup requirement is a white background with a ruler as reference object. The algorithm developed assumes that on the right of the subject, there will be a ruler that serves as the reference object. From a sample of 30 students taken from Inchican Elementary school, the margin of error for the height is +-2.18 cm or +- 0.86 inches. The group was able to achieve its goal and kept the margin of error to a reasonable measurement. For the calculated weight, since Weight D uses Equation 2, the image processing module uses this equation in calculating weight not only because it was modeled using computed height but also due to having the highest accuracy when using calculated height, lowest RMSE and standard deviation.

GeeBeeView is a data visualization mobile application that was designed to display the collected information of GeeBee. It was developed as a completely separate application from GeeBee so that it can function properly even without GeeBee.

The data visualization module of GeeBeeView is capable of presenting the individual health results of a single child and the aggregated results of a group of children. The visualization for a single child is a line graph emphasizing the changes of the child's health results over time. The visualization of the aggregated results of a group of children is interactive in the sense that it allows addition and removal of datasets and filters and changing of chart types. The visualization of aggregated results can be used to compare two sets particularly the contents of the dataset list and a larger set however, this is only applied for the pie and bar charts.

The cloud computing functionalities added to GeeBee and GeeBeeView was designed to cater to both applications in unison. Both applications with their local database counterparts are all integrated in their respective applications. Both communication with the remote server and their local databases are not necessarily two-way. In the case of GeeBee, the communication with the local database in the remote database are mostly exclusively upload to the remote database, while GeeBeeView is almost exclusively download only. Connections

of the local database to a remote and enabling then to sync is necessary for storing the data in a centralized database to be able to safe keep, organize, and to make data accessible.

With the current stance of the database related functionalities, of both the GeeBee and GeeBeeView applications, the database algorithms used and presented only used minimal optimizations for uploading and downloading data. In the sense of uploading data, it includes uploading bytecodes and binary data from images and audio. Future researchers should opt to try compression of data as with the combination of both bulks of audio binary data, image binary data and text, it could prove to make uploading faster and easier also limiting data storage consumptions.

GeeBeeCapture can be improved if it can accurately calculate the height and weight of its subject without the need for a reference object. Furthermore, GeeBeeCapture can be improved if the clothes of the subject do not affect the calculated weight. There are times wherein the clothes extend and are included in the measurements of the width, which may affect the calculated weight.

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