Integrating Patient Information and Research Data for Maxillofacial and Craniofacial Domain into a Single Database

Fariza Hanum Nasaruddin, Maizatul Akmar Ismail, Somasundaram Nagappan*
Faculty of Computer Science and Information Technology
University of Malaya
Lembah Pantai, 50603, Kuala Lumpur
MALAYSIA
fariza@um.edu.my, maizatul@um.edu.my, fsktm98@yahoo.com*

Abstract: -
Research in the area of maxillofacial and craniofacial surgery almost always comes from images of patients. This paper discusses the possibility of integrating the database for daily medical operational needs together with data for research purposes in the area of maxillofacial and craniofacial surgery. Currently, medical institutions concentrate on systems which have the main function of managing daily operational data. Even at medical institutions where researches are being conducted, data to be used for research are separated from the data from the hospital system. Maxillofacial and craniofacial surgeries are mostly preceded with the development of models, and this nowadays would mean three dimensional digital models This opens an opportunity for medical team to collaborate with other department for example a team from a computer science department. The main task of the CS team is to develop digital models and part of the ongoing research would be on modeling techniques to improve the design of the models. The data from the surgical team can be used the CS team and stored data and models can be reviewed by surgical team to analyze past procedures, diagnoses and prognoses. The design of the database and the system architecture of the proposed system are discussed in this paper.

Key-Words: - research database, image data, maxillofacial data, craniofacial modeling

1 Introduction

The face is possibly the focal point of a person, otherwise there would not be many works of art dedicated to it. As such, any deformation to the facial area could be devastating to the person. In cases of malformation or injuries which affect the facial region, reconstructive surgery is a very attractive alternative. Reconstructive surgery is not only applicable to accident victims but is a feasible solution to those with conditions suffered from birth. Surgery to the facial area may involve the maxillofacial and craniofacial regions. As with many other domains, the computer has become a valuable tool to assist medical practitioners in various ways. Using the computer as a tool, reconstructive surgeons can make use of digital models to assist in pre and post operations. This has been reported in various articles such as [1]. But in addition to using the computer to assist in creating virtual models either in 2D or 3D to assist in preparing for surgery and comparing results after surgery, computer systems has long been used to manage patient data in daily operations at a hospital . Then there is also the need to conduct research to improve modeling techniques and also surgical techniques, and [1] reported the use of computer for such purposes. Therefore, it is without any doubt that the computer has been used to assist in the domain of maxillofacial and craniofacial reconstructive surgery, either to assist directly with preparation and planning of the surgery itself, to be used in evaluating the success of the operation, in managing patient information, and as a tool to help in other additional researches in this area. However, in many cases these computer systems exist as separate entities from each other. In this work, we study the needs of a maxillofacial & craniofacial reconstructive surgical team and its members with respect to their use of computer systems as a tool to assist them in their surgical preparations and the possibility of using the same system for other purposes such as patient management and research. The objective of this research is to eventually propose a more comprehensive system that could improve the management of data and information surrounding the maxillofacial and craniofacial surgery for both daily operations and research purposes.

This paper will begin with a review of literature, followed by a short discussion on the approach used for this project. Then it will continue with a discussion on the findings which becomes the foundation for user requirements in determining the proposed system. It

then discusses the data model for the database and the model of the proposed system. The paper will end with a discussion of the system's limitations and suggestions for future enhancements.

2 Literature Review

The main objective of the research is to design a proper database system that can be used by both the medical personnel who attend to patients, and the researchers who conduct research to improve the understanding and techniques related to the maxillofacial and craniofacial surgery either directly or indirectly. To do this we will first look at the various information systems which are commonly used in hospitals, and databases used by researchers. Then we also need to understand the area of craniomaxillofacial surgeries to be able to acquire better requirements for the system that is to be proposed.

2.1 Related Systems and Databases

While true medical institutions would be more interested implementing a centralized and integrated health information system, in a teaching hospital where researches are continuously being conducted, there should be a system that handles not only patient data, but data related to research as well. Although the ideal situation would be to have a completely integrated system, this is not an easy task as there are many barriers to implement one [2]. In this case, we see the need to combine the data from the health information system and the research information into a single system.

Before we propose an integrated system, let's take a look at some of the information systems being used in the medical environment which are related to the topic of our research. The most common system used by hospitals comes in the form of hospital information system (HIS), electronic medical record, clinical information system, and various other systems which uses other names. The main function of this type of system to manage data and information in relation to patients; their diagnosis, treatments and so on. So much so, the Electronic Medical Record (EMR) which expressly reflects patient diagnosis processes has become one of the main focus of HIS [3]. The functions of a Hospital Information System may include additional features such as orders for prescriptions, orders for tests, viewing of laboratory or imaging results, pharmaceutical, and other module as shown in the figure 1.

Of course HIS would also include administration of the hospital but this area is not of concern to this particular work and therefore is not discussed here. The focus is to look at what data is stored in a HIS, and the figure below illustrates an example of what entities are relevant in a hospital information system.

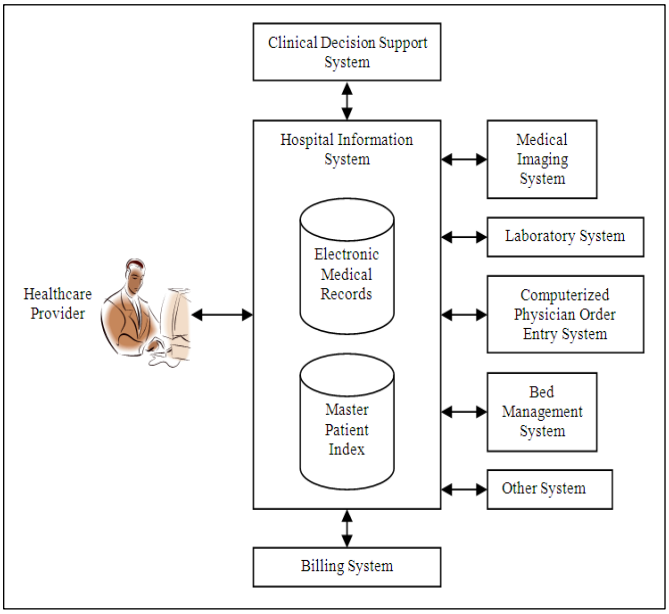

Fig.1 Modules within a Hospital Information System [4]

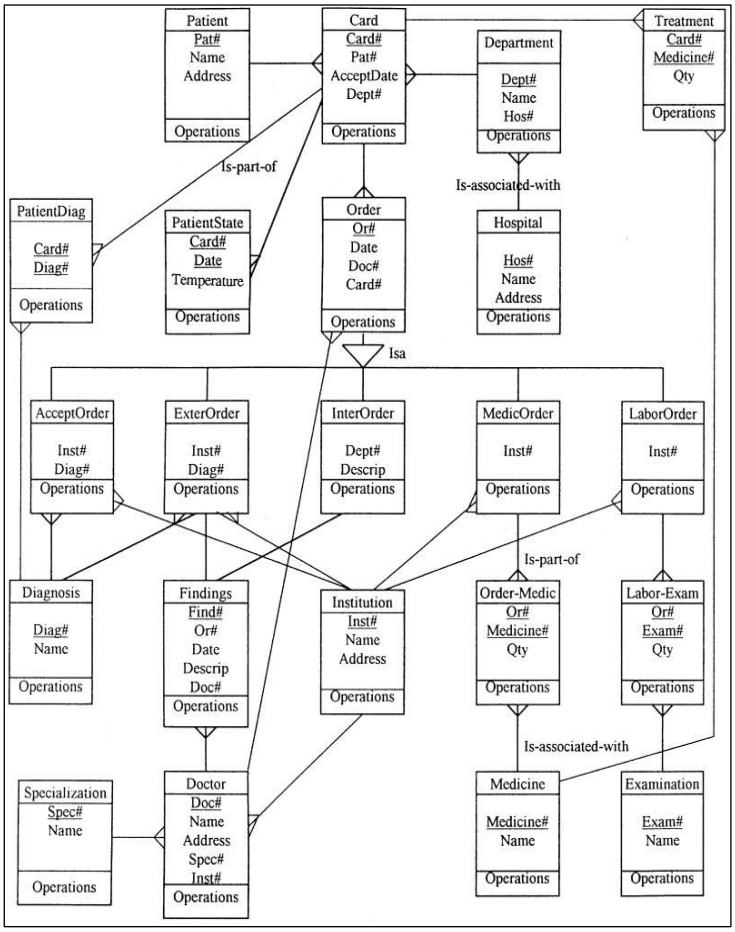

Fig.2 E-R Diagram showing entities relevant to a Hospital Information System [29]

A hospital might also include a Picture Archiving and Communication System (PACS) and Radiology Information System (RIS). Both are mainly used by the radiology department; the first, as a database that stores different types of images taken by the radiology department with relation to patient and their condition, and the other to manage radiology resources and manage patient scheduling. Traditionally a RIS takes care of examination schedules, and allows for management of diagnosis report, while PACS takes care of imaging process and manage data storage and access. The figure below from [5] illustrates the different functions handles by PACS and RIS.

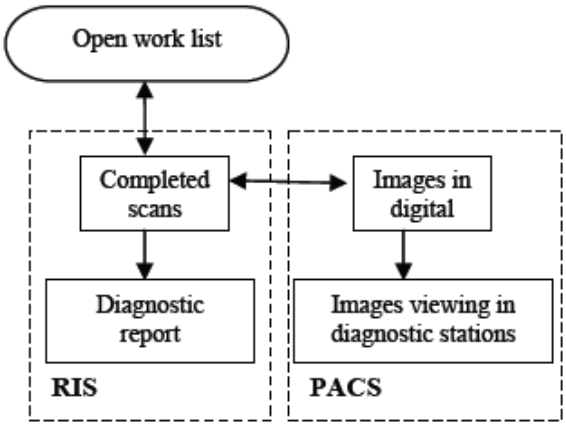

Fig.3 Differences between RIS and PACS [5]

More often, these two systems are found together, although not necessarily so. Ideally, both of these systems should be linked to the patient's electronic medical record and should be accessible from anywhere in the hospital by authorized users [6].

Besides systems at hospitals, let's take a look at other storage areas which may house data concerning maxillofacial and craniofacial surgery. Setan, Majid & Suwardi [7] developed an image capturing system and information system for craniofacial reconstruction. Their system is mainly focused on capturing the images of craniofacial for reconstruction purposes, Their images must be very accurate to enable them to carry out very precise and accurate measurements. A diagram of the flow of the capturing process of the image to the final output is shown in Figure 4.

Setan, Majid and Suwardi are not the only ones working on collecting images for reconstruction data. There are other facilities which own databases with such adta. AN example is the MORPH database owned by University of California Wilmington (UNCW). The data from this database is available to researchers on a case-by-case basis and formal written requests must be made to the center before the data can be released [8]. This is partly due to the fact that data belongs to the institution that created it, a point that will be discussed in section 4.3.

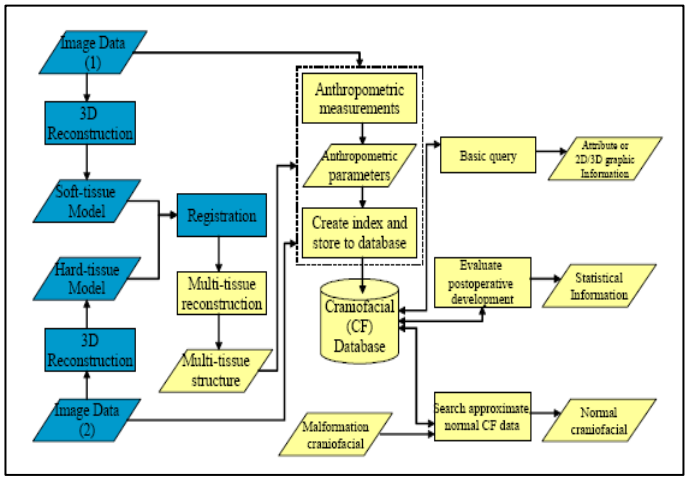

Fig.4 Image Capturing System [7]

Another database that houses craniofacial images is the Craniobank (craniobank.wustl.edu) at Washington University in St. Louis [9]. See figure 5 below. It is an online databse which allows for free access for users to search for naormative craniofacial images of children from infants to age 18. This database also encourages researchers to contribute their data to the database to be shared by the rest of the interested parties.

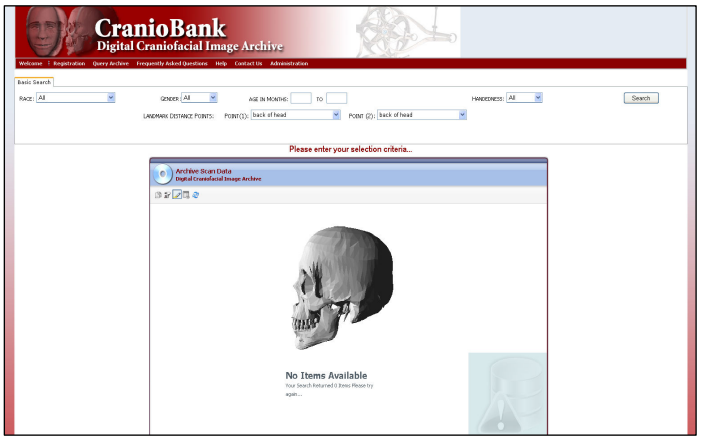

Fig.5 Craniobank.wustl.edu [9]

As a matter of fact, there has been a growing interest in the development of databases for research projects data related to health and diagnostic images. For example, many developments of databases for cardiac related project has been and are being carried out such as

discussed in [10,11,12,13,14,15]. All these have shown that the development of a database for maxillofacial and craniofacial is a relevant work to be carried out. The only difference in these developments is the requirements of the stakeholders and users of the system.

2.2 Maxillofacial and Craniofacial Surgery

The area of the head is also known as the cranium, and the term craniofacial refers to areas of the head or the skull plus the facial region. Maxillofacial refers to the maxilla area which is the pair of bones of the human skull fusing in the midline and forming the upper jaw. Defects in the area of craniofacial and maxillofacial may be due to injuries, diseases or congenital malformations. Treatment, most times involve surgery in this area. Surgeries often involve treating the abnormalities by bone fragments repositioning, bone defects restoration, and implant insertions [16] [17].

The anatomy of the craniofacial and maxillofacial region is complex [23]. And to perform surgery on this area is no easy task. It is almost mandatory that surgeons be able to foresee the new facial outlook of the patient prior to performing the operation. Reconstructive surgery most often requires a model to visualize the face that needs to be reconstructed. To do this, data is required for the modeling process. In many cases, the data are scans of the patients face. As early as 1980, the importance of 3D models have been recognized to be useful in preparation prior to surgery[18]. The 3D models were produced by transferring contours from CT scans onto plastic plates and sticking them together [18]. However, with the advancement of computer technology, digital models in 3D are now a possible and better alternative.

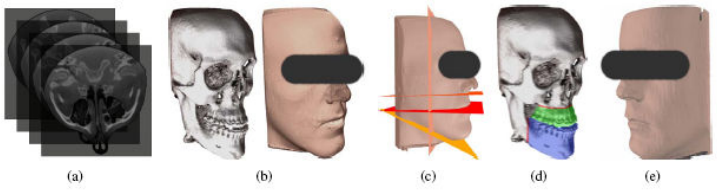

Figure 4.
(a) DICOM images,
(b) hard and soft tissue before surgery,
(c) surgery planning over soft tissue,
(d) pieces identified for simulation, and
(e) simulated model [18]

Research in maxillofacial and craniofacial domain can either be towards improving the medical knowledge such surgical techniques, patient diagnosis and prognosis, and surgical planning [16][19][20]. However, there are also researches conducted by non-medical teams such as a computer science team which studies techniques of digital modeling to produce better models using available data. Some examples are researches on graphical and visualization techniques as described by [21] and [22]. Many of these researchers require raw data such as CT and MR (Magnetic Reasonance) images. For researchers who are affiliated with medical institutions, although these data are already available in the hospital's PAC system, these researchers do not have direct access to them. Issues such as patient confidentiality and ethics come into play, which inhibits their direct access. Therefore, there should be a way how these data can be made available to researchers, while taking into consideration the issued mentioned earlier. One way is to integrate these data into research databases with the necessary filtering, as will be discussed later.

2.3 Finding research information

The actual data such as the CT and MR images are used in the planning the operation and also in researching better ways to assist in this planning. Reports from such researches are mainly reported in publication of articles in journals, proceedings, and even technical reports. When a researcher wants to start a research, one of the activities he or she will want to carry out is to study relevant work done in that area of research. Similarly, the researcher who is going to conduct research to find better ways to assist in the planning of a facial operation or any other research for that matter will want to find out relevant works via publications of articles.

Currently, articles regarding relevant works are found in digital libraries and other similar locations. Researchers have to use their experience in locating and finding information pertaining to the research they are interested in. [Maizatul et al] reported that while this is easier for experienced researchers, new or novice researchers need help during this activity. In a learning institution where researches are continuously being conducted and new researchers are being engaged, it would be beneficial for the institution to provide assistance to these novice researchers [24]. This becomes of the criteria considered as one of the requirements for the database that is designed for maxillofacial and craniofacial data.

2.4 Research Data & Its Characteristics

Although Maizatul et al are more concerned with providing assistance to novice researchers, Nasaruddin

is more focused in tracking which data is related to each other so that researcher who is interested in a particular data will be aware if the data has been pre-processed so that redundant work will not be carried out [25]. In another article, Nasaruddin and Narainasamy discussed similar concept to trace the origin of a dataset and all other related data which has been produced by the same original data [26]. One of the main reasons for doing this is because one original set of raw data may have to go through various processes before it can be used in a particular research work. This fact is observed by Nasaruddin [27] and Xia et al [28]. The following figure 3 illustrates the various processes which one dataset can go through and each process resulting in a new set of data (model).

As can be seen in the figure 5, the original image captured was processed in five stages, and each stage resulted in a new set of data. For example, in stage 3, facial features were extracted which provides two sets of data; the frontal view and the right and left views in 2D. The interesting point is that this process of processing data and eventually gaining a new set of data as output is not just the case for craniofacial data. This flow is also common in other datasets as observed by Nasaruddin [27]

The reason for this is so that if need be, researchers can find the same data that was used for a similar procedure so that comparisons can be made on the result of the procedure. Different researcher may use the same data set and using different algorithm may produce different results. The results from the different algorithms can then be compared if both of them use the same set of original data. All these ideas of providing the researchers with not only the report / articles regarding the research, combined with the need for information regarding the data itself become the premise of investigating whether such requirement is indeed useful.

3 Methodology

Before a system and a repository for the datasets can be designed, first we need to understand the data and how they are used. We need to study the potential users and how they are going to use the system and the data. This work employs the case study as a method of research. Observation and interviews are the instruments used in this work to collect data and information. Based on the collected information, a conceptual data model for the repository is designed together with the system architecture. In this paper, the first version of the data model and system design is made available for discussion. However, at the time this paper is written, further enhancements are being made to the designs as new requirements are considered.

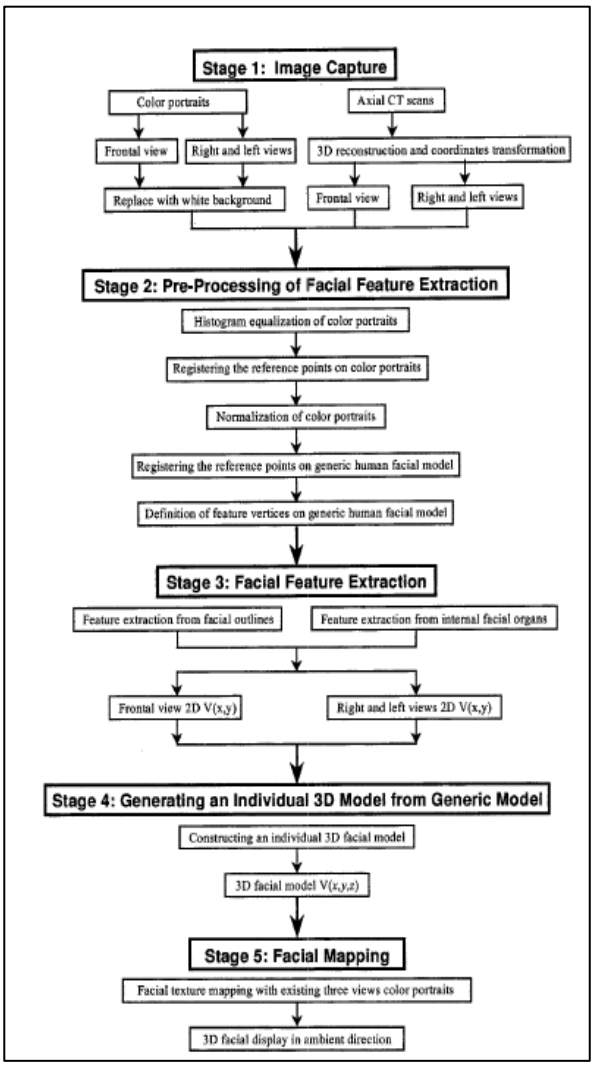

Fig 5. Steps in Facial Model Generation [28]

3.1 Problem Statement

This development work was triggered after observing the collaboration between a reconstructive surgical team at a prominent university medical center with a computer science team at the same university. The main actor in this case is the surgical team. The team requires digital models for the preparation and the planning of the surgery. For this, the computer science team is consulted. There is a natural need for collaboration between these two departments due to its requirements. As a result, both departments are now collaborating to improve services to patients. Their collaboration include preparation of digital models for pre-operation planning and post-operation analysis, and at the same time the computer science department is able to conduct more research in digital modeling using the MRI and CT data

scanned by the surgical team. As the computer science team works with the surgical team, its members start to study how to improve the modeling techniques. Techniques in visualization and rendering of images are also becoming another research possibility. These studies are beginning to attract more students and researchers and a research group is established. Soon, new research members need to lookup older scanned data and models created earlier as well as information regarding previous researches that have been conducted. Publications relating to the research can be helpful to new researchers. At the same time, as more and more digital models have been developed, surgeon can review past cases for analysis or comparison of techniques. As this is a teaching medical institution, past cases can be used as teaching tools and training.

Currently, the image data that are scanned of each patient are used for pre-op preparation and are stored without much concern for further access. Digital models which have been constructed for each patient are also stored in such a manner. Since it takes considerable money, time and effort to create datasets such as scanned images and digital models from scratch, they should be made available to other potential researches. The final aim of this project is to build a repository system for such datasets that can be accessed by both medical and non-medical personnel.

3.2 Requirement Analysis

The surgical team consisting of two collaborating departments has taken the initiative to manage their data. As a medical unit, first and foremost, the team needs to track information of their patient and to monitor the status of the patient's treatment. Currently, the team keeps track of their patients via a simple worksheet style repository. The repository consists of a number of tables which tracks the progress of the patient in relation to the stage of the process; ie. whether scans of the patient has been acquired, whether a model from the scan has been generated, whether the implant that is to be used in the surgery has been sent for fabrication, and so on. Information regarding the diagnosis of the patient is also stored in one of tables. Other information includes the surgeon in charge of the patient, surgery date information and so on. Besides those information mentioned earlier, the team also stores the scans taken from the patient. These scans are used for the development of the 3D model as one of the pre-op preparation. We know that this is the data used mainly for the medical side of the team. However, the team members from the computer science department who are collaborating with the surgeons are not only assisting in the development of the patient's cranio-maxillofacial models, but they are also conducting research on the techniques to produce better and more accurate models. New analysis techniques are also explored using these models by the CS team. Currently, these team members organize and manage the CT scan and MRI data by keeping track where the data is located. These scans consist of very large files which makes it difficult to store them in a conventional DBMS. Although now it is not impossible to search and access these scanned files, by not storing them in a DBMS makes it more difficult to search and access them. An important issue which needs to be considered when it comes to medical data is the security of the data and the privacy of the patient's information. It is worth mentioning that currently, there is no direct way to access a previous case according to certain attributes. For example, what is a surgeon wants to review a case he handled a few years back, which he feels have similarity with a current case. Currently, search has to be made according to the previous patient's id, and then the files' location will have to be extracted from another table. Then the files can be accessed from its storage space which could be in any one of the collection of hard disks.

4 The Proposed System Design

From the initial requirement analysis, the main data that need to be stored and accessed are classified and categorized. Functional requirements are determined and mapped into system modules and functions. The following sections discuss the initial proposal.

4.1 Database Design

As this is a proposal of a database system, the design of the data model is very important. For the proposed system, there are three main types of users; surgeons, medical personnel, and researchers. The modelers are categorized in the researchers group. The design of the database begins by studying the external views of these users. These different views are consolidated into a conceptual data model shown in Figure 6.

The main bulk of the data is the scanned images, photos, and the digital models developed from the images. In terms of its entities and attributes, these data is closely related to the data available on the PACS. In the figure 6 above, this group is labeled Maxillofacial and Craniofacial data. This group of data is usable to all three types of users. The next group of data is data that closely resembles the EMR and the HIS. In the figure 6 above, this group is referred to as Medical Info. This data is mainly accessed by surgeons and medical personnel. The last group of data is data that is related to research. This group of data is an extension of a publication database which stores the publications by the team members, but at the same time links each publication to the dataset that is relevant to it. Each publication and the dataset are linked to a researcher and

his/her research area. This group of data is to help in finding information regarding in that domain.

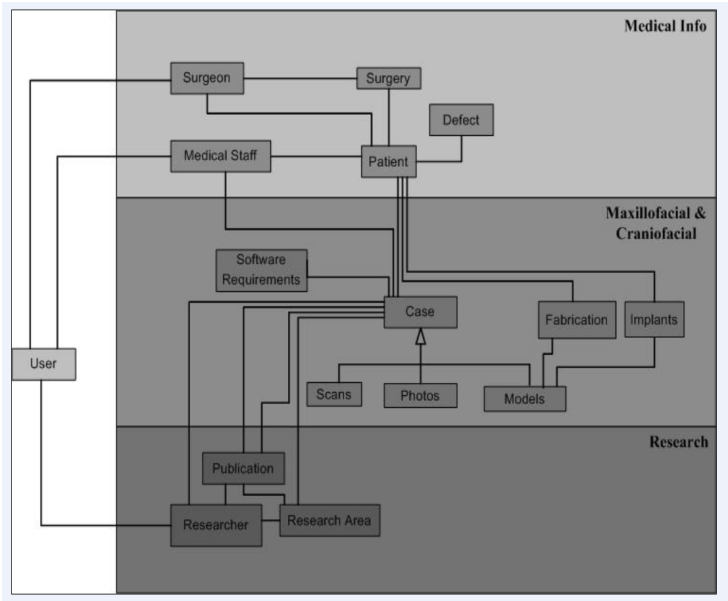

Fig.6 Conceptual Model of the Proposed Database

The variables used for the research publication entity will be the common variables used in most digital libraries. Metadata from Dublin Core and other publishing sites are compared and common metadata are adopted for this entity.

In addition to that, the publication will be tagged with the dataset that was used in that research work. The reason for this is to assist researchers in getting full information regarding the research work and also to help with the query of relevant work done with that particular dataset.

4.2 System Architecture

In this section, the main modules of the proposed database system are presented. The proposed system architectural pattern consists of three main layers: The "Client" layer, which is responsible for displaying and reading data from “Application” layer, and lastly the "Physical” layer which has the responsibility of communicating with the database section. The “Application” layer comprises of five managers: namely Security Manager, Query Manager, Download Manager, Upload Manager, and Data Manager, as illustrated by Figure 7.

In this proposed system, any visualization tool or software will be placed at the “Client” layer. Information regarding which software is required for which data is supplied to the user when the data is accessed. The user is responsible in acquiring the necessary tool which is required. Before users can access the system from the “Client” layer, the Security Manager will determine the access level of the user. The Security Manager is responsible to monitor what functions each user is allowed to perform.

Once the user is logged-in, he/she can perform query. However, only data that is allowed for the user can be viewed. This takes care of the privacy issue regarding patient information. For example, a researcher will have only limited access to patient information. He/she will not be able to view information regarding a patient, such as name, unlike surgeons and medical staff. User can opt to download data for their use, either for modeling, analysis, and so on. Again, this feature is also monitored by the security manager.

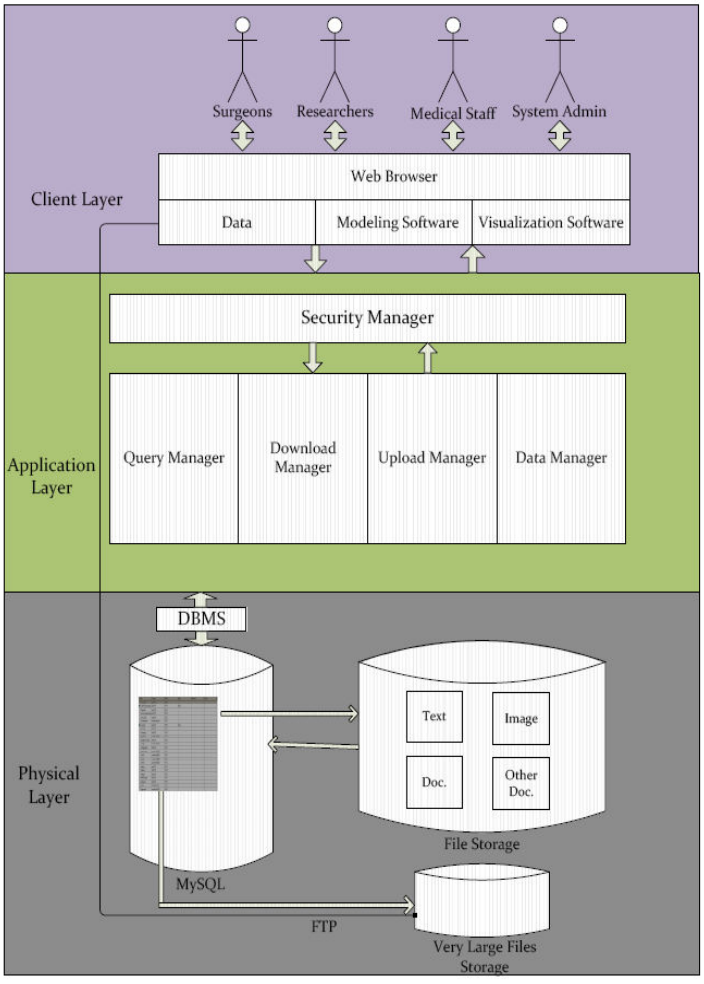

Fig.7 Architecture of Proposed System

The database is populated by the users themselves via the Upload Manager. However, once the data is uploaded, it is not automatically accessible to users. The system admin is responsible to check the authenticity of the data and that it is free from viruses. Only approved data can be made available to users within specified parameters. Lastly, the Data Manager is responsible for

management of user profiles, log activities, and data maintenance, such as edit, and data deletion.

4.3 Handling privacy issues

One of the main concerns plaguing data storage is privacy and security issues. Data created at an organization, which includes diagnostic images such as x-ray, CT scans, MR images, ultrasounds are the property of the facility that prepares them. Stakeholders are very wary regarding the security of centralized data repository and this is a strong issue that needs to be addressed in any database development. This is one of the reasons why researchers find it very difficult to access data straight from a database owned by a medical institution, even though the data they require and can use can be easily found there. This is one of the reason why it important for researchers to maintain their own database of data which they have collected, some of which may be data from hospitals which have been processed to alleviate any security and privacy issues.

In the database for research, the security and privacy measures can include differentiating different level of access for different users. The security manager of the database system can easily differentiate those who are medical staff and who are researchers and what access level they are granted. This is a plus to the database system because it has already taken security and privacy into consideration so that researchers cannot simply access any data they want, but at the same time, the researchers are nit denied the data that they need.

5 Discussion of Limitations

The proposed system is suggesting that patient data and PACS data should be integrated with research data for use at a learning hospital. This work acknowledges that there are more entities and attributes that need to be included in the database if it was to be deployed and used in a real environment. The Medical Info data should incorporate all of the data available in EMR if it were to properly monitor patients. However, the proposed system is to promote the possibility of integrating all of the data and is to be used to illustrate the concept. Another enhancement to the system is to add the facilities available within PACS such as visualization tools into the system. Future work could include the use of ontology rather than key-word retrieval in order to optimize the searching facility. Another enhancement would be the use of content-based retrieval for image related data.

6 Conclusion

The proposed database system is designed to integrate data needed by three groups of users working together within the domain of maxillofacial and craniofacial surgery. Although similar systems are available, each of the system now exists as separate entities. The motivation is based on the study of a surgical team at a learning medical institute. The current data management tool used by this team does not allow for easy access and searching. Therefore this proposed database system is expected to improve the data management for this team.

References:

[1] M. Chabanas, V.Luboz, and Y. Payan., Patient specific finite element model of the face soft tissues for a computer-assisted maxillofacial surgery, Medical Image Analysis, Vol 7, pp. 131 – 151, 2003.

[2] Culjak, G. and Kalkvik, A., Centralised Health Information Systems: Overcoming the Barriers, WSEAS International Conference on Applied Computer Science, Vol.6, pp.419-424, 2006.

[3] Hong-min, R., Jing-zhou, Z. and Zhi-ying, Y., Research on Regional HIS Interconnection Architectures Based on Electronic Medical Record, wcse, vol. 1, pp.84-88, World Congress on Software Engineering, 2009

[4] Nasaruddin, F.H, Integration Of Healthcare Information, 7th International Conference on Information Integration and Web-based Applications & Services (iiWAS2005), Vol 2, Sept 19-21, 2005, Kuala Lumpur, pp. 789 – 793.

[5] Ortiz-Posadas., Benítez-Graniel. and Pimentel-Aguilar., PACS: Reengineering Workflow in the Imaging Department of a National Health Institute in Mexico, Engineering in Medicine and Biology Society, 2007 Annual International Conference of the IEEE.

[6] Jiménez-Herrera, A., Avilés-Cruz, C., and Arechiga-Martínez, R., Minimum PACS system based on DICOM standard, the 11th WSEAS International Conference on Comuters, pp.234-240, 2007.

[7] Setan, H., Majid, Z., Suwardi, D., The Development of Image Capturing System and Information System for Craniofacial Reconstruction, 3rd FIG Regional Conference Jakarta, Indonesia, October 3-7, 2004

[8] Karl Ricanek, Jr. and Tamirat Tesafaye, "MORPH: A Longitudinal Image Database of Normal Adult Age-Progression", *IEEE 7th International Conference on Automatic Face and Gesture Recognition*, Southampton, UK, April 2006, pp 341-345.

[9] CranioBank : Digital Craniofacial Image Archive, https://craniobank.wustl.edu

[10] Antoine Rosset , et al., Casimage Project - a digital Teaching files authoring Environment. *journal of thoracic imaging*, 2004. 19(2): p. 1-6.

[11] C.S.Candler, S.H.Uijtdehaage, and S.E.deniss, introducing HEAL:The health education assets library. *Academic medicine*, 2003. 78(3): p. 249-253.

[12] Jon J. Campa, et al. System for the analysis of whole-bone strength from helical CT images, *SPIE*, 2004.

[13] Muller, H., et al., Evaluation Axes for Medical Image Retrieval Systems-the Image CLEF Experience, *ACM Press*, 2005.

[14] Wei Wang and P.M. Barnaghi. Semantic Support for Medical Image Search and RetrievaL, *International Conference on Biomedical Engineering (BioMed 2007)*. February 14-16, 2007.

[15] Cao, P., et al., An integrated medical image database and retrieval system using web application server. *international journal of medical information*, 2003. 71: p. 51-59.

[16] Rana, A. M., Setan, H., Majid Z., and Chong, A. K., Simulation of Interactive Cutting Tool for Craniofacial Osteotomy Planning, Computer Graphics, Imaging and Visualisation (CGIV 2007), cgiv, pp.506-512, 2007

[17] Booth, P.W., Eppley, B.L, Schmelzeisen, R., Maxillofacial Trauma ans Esthetic Facial Reconstruction, Churchill Livingstone, Edinburgh, 2003.

[18] Santler, G., Kircher, H. and Ruda, C., Indications and limitations of three-dimensional models in cranio-maxillofacial surgery, Journal of Cranio-Maxillojacial Surgery (1998), European Association for Cranio-Maxillofacial Surgery, Vol. 26, Issue 1, pp.11-16, 1998.

[19] Olszewski, R., Villamil, M. B., Trevisan, D. T., Nedel, L. P., Freitas, C., Reychler, H. and Macq, B., Towards an integrated system for planning and assisting maxillofacial orthognathic surgery, Computer methods and programs in biomedicine 91, Vol.1, pp.13–21, 2008.

[20] Buchart, C., San Vicente, G., Amundarain, A., Borro, D., Hybrid visualization for maxillofacial surgery planning and simulation, 13th International Conference Information Visualization, 2009, pp. 266 – 273.

[21] Cheng, I., Nilufar, S., Basu, A. and Goebel, R. Shape Tracking and Registration for 4D Visualization of MRI and Structure, Springer-Verlag Berlin Heidelberg, Vol. 4292, pp. 253-262, 2006.

[22] Harun, W. A.R. W., Rajion, Z. A., Aziz, I. A. and Samsudin, A. R. 3D CT Imaging for Craniofacial Analysis Based on Anatomical Regions, the 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference, Vol. 1, pp.517-520, 2005.

23] Yavuzer, R., Book Review of P.W. Booth, B.L. Eppley, R. Schmelzeisen : Maxillofacial Trauma and Esthetic Facial Reconstruction, European Journal of Plastic Surgery, Vol.27, pp.352, 2005.

[24] Ismail, M. A., Yaacob, M., Kareem, S. A., Nasaruddin, F. H., Assisting Novice Researchers in Utilizing the Web as a Platform for Research: Semantic Approach, WSEAS Transactions on Information Science & Applications, Vol. 6, Issue 1, pp.211-220, 2009.

[25] Nasaruddin, F. H., Zakeryfar M., Ahmad, R., Development of An Online Image Repository System for Cardiac Modeling, WSEAS Transactions on Information Science & Applications, Vol. 6, Issue 1, pp.222 -231, 2009

[26] Nasaruddin, F.H., Narainasamy, S., Proposed Framework of Cardiac Data Repository for Virtual Heart Project Research Team at University Malaya, Proceedings of MRG International Conference 2006, Manchester, UK., pp 323 – 329, 2006.

[27] Nasaruddin, F.H., Data creates more data : A study of the Datasets used by Virtual Heart Project Research Team at University Malaya, International Conference on Electical Engineering and Informatics, Bandung, Indonesia, 2007.

[28] Xia, J., Wang D., Samman, N., Yeung, R. W. K., Tideman, H., Computer-assisted three dimensional surgical planning and simulation: 3D color facial model generation, International Journal of Oral and Maxillofacial Surgery, Volume 29, Issue 1, pp. 2-10, February 2000

[29] Talib Damij Development of a Hospital Information System Using the TAD Method, J Am Med Inform Assoc. 1998 Mar–Apr; 5(2): 184–193.