1.0 INTRODUCTION

Data collection and analysis have become a driving force in medical innovation, and pathology and laboratory science are no different in accumulating large amounts of data within a short time. Incorporating scientific research, such as genomics, proteomics, bioinformatics, and biostatistics, into clinical practice opens the door to new approaches to patient treatment. Computational pathology is an emerging discipline that promises a more integrated solution to whole-slide pictures, multi-omics data, and clinical informatics.

Pathology informatics is the study of the ways computers and information technology are used to organize and process pathological data. It is an emerging discipline of biology which has evolved as a result of the rising amount of data provided by pathology laboratories. Such large pathological information or data is stored, retrieved, and analyzed using pathology informatics tools and methodologies. Pathology informatics is an essential component in the modern-day healthcare system where it aids pathology laboratories in managing the massive amounts of data they produce over time. Pathology informatics technologies and approaches are also employed to help with research and patient treatment.

PathoNecticss is a computational pathology system that has the potential to revolutionize not just the developing sub-segments of digital pathology, molecular pathology, and pathology informatics, but also the conventional core activities of pathology. By bringing global collaboration, PathoNectics aims to improve diagnostic accuracy, optimize patient care, and reduce costs anywhere necessary. Hence, Pathonectic aims to obtain individualized precision medicine, which is being driven by fast technology innovation where these sorts of aspects are applied to the system software in giving out accurate and precise information and data to be used and applied by pathologists or any relevant medical field that utilize such services. Moreover, PathoNectics also directs its sights on improving patient care. With the help of PathoNectics tools and techniques, pathologists could produce a more specific and precise diagnostic which could shorten the time for targeted treatment leading to improved patient care.

On top of that, PathoNectics could aid pathologists in being more efficient by cutting out unnecessary costs in the laboratories. Menial tasks such as data analysis and entry can be inputted automatically by using the PathoNectics software system with the aids to pathology informatics tools in order to increase the efficiency of workflows which in turn will reduce the time and energy needed to manage a massive amount of pathological data to be registered or

inputted. In addition, this system could also play a major and critical role in aiding medical research by utilizing various informatics tools and techniques available, pathologists are able to leverage PathoNectics to analyze large biological and pathological data quicker and with high accuracy. This in turn could shorten the research time and lead to more advanced treatments for a range of diseases or ailments.

In conclusion, pathology informatics software is a crucial component of medical tools for the modern healthcare system where many major hospitals, laboratories, and research centers rely on such software to analyze, retrieve, and store a larger amount of pathological data with precision and efficiency. In addition to that, the system PathoNectics employs will also enable a more structured synergy between various healthcare professionals that transcend across different disciplines globally in providing better quality and safety when it comes to patient care with the aid of pathology informatics software.

2.0 THE USER REQUIREMENTS

PathoNectics systems will be used to store, manage, and analyze digital pathological data and images with high efficiency and robustness for optimum patient care. Hence some of the user requirements for this system include:

1. Registration and Login
   - Pathonectic allows its user to register with the system by creating an account and login into their account. In addition to that, a registered user is able to utilize the full potential of the PathoNectics system on top of being able to save any pathological images or data to the cloud without having to rely on any third-party applications.

2. Account Management
   - PathoNectics allows its user to manage their account including updating their account information, personal information, email addresses, passwords, shipping and billing addresses, payment methods, and more.

3. Mobile Access
   - PathoNectics systems are also compatible across different dimensions of devices ranging from portable laptops to smartphones with a responsive interface design that could adapt from large screens to smaller screens without interrupting the interface layout.

4. Data and software portability
   - PathoNectics will be able to be shared and be used across different types of system software ranging from MAC os to Linux.

5. Image Management
   - PathoNectics allows its user to upload, store, modify, and manage its data and pathology digital images in addition to various editing tools such as annotation and image enhancer or labelling functionality. On top of that PathoNectics also consists of specimen tracking and analysis of selected pathological images or data in 3 dimensional for a better understanding of the data with the aid of AI embedded in the system.

6. Data Management
   - PathoNectics enables its user to manipulate, manage and analyze any data of interest or associated data ranging from patient information, specimen information, collaboration information, test results, diagnostic methods, and more

within the capability of the system's pathological tools. PathoNectics will enable its user to keep on tracking or archiving interested pathological data easily as well.

7. Analysis Tools

    ○ PathoNectics will provide tools capable of analyzing pathological images or associated data at a rapid speed and efficiency which will be aided by an image segmentation feature, data extraction and identification, and classification of the pathological data or images by the user. In addition to that, PathoNectics will also employ the usage of AI in aiding pathologists or its user when it comes to analyzing any associated pathological data in order to produce more accurate analysis with the lesser time required.

8. User Interface

    ○ PathoNectics will employ a user-friendly interface which is easy to navigate through where users will only have to go through minimal to no training at all when using the system.

9. Support and Training

    ○ PathoNectics contains complete digital documentation which pertains to guidance and training modules for all users. This is to ensure that all users are able to effectively utilize the system's quirks and features to their fullest. In addition to a complete set of guidance offered, the system will also have technical support that is available 24 hours a day, seven days a week, for its user to allow for a better experience when navigating through the system.

10. System Availability

    ○ PathoNectics systems are accessible 24 hours a day, seven days a week, however, this may vary depending on local conditions. Appropriate standby and assistance plans will be in place to guarantee that service delivery continues in the event of failure of the IT system.

11. Collaboration Tools

    ○ PathoNectics allow its user to collaborate with other users which will be managed by the collaboration tools embedded in the system. Such tools include sharing of pathological data and images which allow the user to share with other users for collaborative work on a project.

12. Integration with other systems

- PathoNectics is able to integrate with other systems easily. For instance, PathoNectics are able to integrate with any clinical and laboratory system such as Laboratory Information Systems (LIS) or Electronic Medical Records (EMR) that are compatible and meet the security and regulation requirement.

13. Security
- PathoNectics will have appropriate security that complies with the current regulations and guidelines in order to protect its user and patient privacy and data, as well as the integrity of the system. In addition, PathoNectics will employ an access level security protocol where only a certain level of the system can only be accessed by users with authorized access.

3.0 DATA STORAGE & MANAGEMENT

Data storage and management are described as the techniques of collecting, storing, organizing, maintaining and protecting data in an ordered and secure manner. The lifecycle of a data, from the beginning and creation of the data till the deletion is maintained by data storage and management. Data storage involves the physical and digital infrastructure in which the data is stored, whereas data management revolves around ensuring the accuracy and accessibility of data. These processes are considered to be key factors in a system as they are essential for organizing, data security and improved decision-making and productivity.

Data storage in PathoNectics involves capturing and storing a wide range of pathological data obtained from patients, diagnostic interpretations of the histology and laboratory test data. The Database Management System (DBMS) is utilised in the informatics system to store the pathological data accordingly. The data obtained by PathoNectics typically comprises of a range of data types such as numerical, image, textual and more. The process of organizing the data in a table is conducted by the DBMS where each table is categorized and contains the information regarding a specific type of data. For instance, the pathological data can be related to the patient demography (patient history) in a table and the diagnostic interpretations in a separate table.

To be precise, PathoNectics uses MySQL language, an open-source relational database management language, to create, modify and extract data from the informatics system. The MySQL language was incorporated into the pathology informatics system as it is a flexible data storage system with a user-friendly interface providing an added security measure feature. The high performance and efficiency of the MySQL language aids the users of PathoNectics to easily access data that are arranged based on various keywords and tags. It provides a structure for the pathological data in the system allowing complex queries and analysis of data. Furthermore, it brings additional features such as data validation, indexing and data backup and recovery making PathNetics well organized.

Data management, on the other hand, involves the process of ensuring the accuracy, completeness, security and accessibility of the data. Data entry, validation, cleaning and transformation are some of the tasks that is conducted under data management of the pathology informatics system. The introduction of digital pathology has posed several challenges in data management including the speed of acquiring pathological images, the amount of data generated, image file formats and legal regulation revolving around the use of

information technology in patient care. Various protocols were formed to tackle these problems such as the Digital Image Communications in Medicine (DICOM) and Open Microscopy Environment (OME).

PathoNectics uses its own built-in data management program to maintain the pathology system. The data management system was developed based on the guidelines and recommendations of the Pathology Analytic Imaging Standards (PAIS) project. The PAIS project was an initiative by the FDA and NIST to develop a standard for image analysis in digital pathology. In addition, the incorporation of the project into the data management program solves the challenges faced by digital pathology. The PathoNectics data management program is capable of conducting the key elements of data management. It is able to conduct data quality control, storage and access of data, data privacy and security, backup and recovery, data archiving, data sharing and collaborations.

The storage and access of data posed a potential problem for data storage and management as the higher the resolution of an image, the higher the file size. Therefore, PathNetics uses hybrid-cloud structure storage as its main deployment because it ensures unlimited storage backed up in scalable servers due to its built-in data redundancy. The data is stored directly in a centralized network attached to storage and is backed up in the cloud. It aids in the system's worldwide collaboration as it is widely available and accessible. The use of the hybrid-cloud storage covers the data backup and recovery as the data backup protocol of PathoNecticss runs multiple times based on a specific iteration cycle into the cloud. The storage platform may seem rather insecure and vulnerable to data breaches. PathoNetcics makes sure the storage platform is monitored 24/7, encrypted and protected with two-factor authentication. Data sharing and remote collaborations were also included as the COVID-19 pandemic has increased the need for such features and tools. Data exchange protocols and standards were implemented to allow the data from PathoNecticss to be shared and exchanged worldwide with various institutions and to ensure data compatibility with other parties.

Data quality control of PathoNecticss ensures the pathological data obtained from hospitals and research centres are consistent. The Open Microscopy Environment (OME) is incorporated into PathoNecticss as the validation technique to ensure the data entry is accurate. OME was selected for PathoNecticss as it functions as a management system to manage and exchange microscopy imaging and metadata. As the data entry contains the personal information of the patients, data security is crucial and in addition to the hybrid-cloud structure

storage security, PathoNectics has implemented access controls and data anonymization aiming to ensure data security and protection of privacy. The data in PathoNecticss is in abundance and data archiving is conducted to keep the least accessed data in long-term storage whilst maintaining the current and recent data in the system database.

Data storage and management is an essential component in PathoNectics as it validates the accuracy of diagnosis, treatment protocols and research of a particular disease. The efficiency of the analysis, improved decision and patient outcomes rely on data storage and management which are critical components in providing data sharing and accurate data by eliminating errors and inconsistent data. In conclusion, the data storage and management of PathoNectics strive for high efficiency and accuracy to help improve the scientific community in future research.

4.0 USER INTERFACE

A user interface is the element of a system or software that facilitates commerce for the user. It features visual factors similar to defences, menus, icons, buttons, and other interactive factors that facilitate tasks and access information. The significance of a user interface is attributed to its capacity to ease the availability, use, and effectiveness of the system or software for users. The user interface(UI) of PathoNetics plays a vital part in assuring that users have an immaculate experience while interacting with the website. It's intuitive, effortless to navigate, and visually appealing, with a system that reflects the professional personality of the pathology field.

An intuitive and straightforward navigation system is a key element of PathoNetics' user interface. As a website devoted to educating pathology professionals, it's essential that users can quickly and easily locate the information they need. The site's content is organized into six logical categories - "About", "Virtual Specimen", "Case Study & Reporting", "Training & Education", "Collaboration", and "Pricing" - each accurately labelled for easy navigation. This approach ensures that users can productively ingress the system's resources to achieve their goals.

The guiding principle of website design lies in the logo's ability to serve as a navigational tool for users. Irrespective of their location within the site's structure, the logo leads them back to the homepage in a uniform and intuitive manner. PathoNetics prioritizes this feature by displaying the logo in the top left corner of every page, rendering it easy to locate and click. This approach guarantees that users can effortlessly return to the homepage, regardless of their activities on the site.

Engagement is a key element of PathoNetics' user interface, with interactive tools taking centre stage. These tools were created to foster an enjoyable learning experience by facilitating pathology comprehension. Virtual slides of tissue samples are easily manipulated by users, enabling them to probe diverse pathology case aspects, surpassing static images' limitations. Furthermore, interactive case simulations allow users to hone their diagnostic skills and gain hands-on experience in a secure environment. The clinical decision support system provides feedback based on user choices, allowing them to make diagnostic decisions with ease.

A flawless design and layout are critical in ensuring a positive user experience on PathoNetics. For this reason, the website constantly maintains an invariant appearance, using

clear visual cues and language to help users navigate and recoup information easily. The point's compatible colours, fonts, and design rudiments, as well as a coherent page layout, all work together to give users the necessary direction to detect the information they need. Besides that, PathoNetics' user interface includes a responsive design where users can enter the website from a range of gadgets, similar to laptops, mobile phones, tablets, and desktop computers. The website was designed to acclimatize to different screen sizes and display resolutions, allowing users to enter content without having to zoom in or scroll horizontally. This compatible user experience across different devices promotes user engagement and encourages visitors to readdress the website.

Overall, PathoNetics UI is crafted keeping in mind the user's objectives, assignments, and predilections. It offers lucid feedback and direction throughout the interaction and is reliable, receptive, and versatile to cater to distinct user requirements and circumstances. PathoNetics user Experience not only enhances usability and user experience, but also improves productivity, reduces errors, and encourages increased adoption and retention, resulting in improved business outcomes.

5.0 DETAILED DESCRIPTION OF THE SYSTEM

The main aim of this PathoNectics is to create a platform whereby pathologists could easily deposit digital pathology images along with their details into this system. In addition, The system aims to provide a pathology informatics system that may enhance and smoothen the process of comprehending histopathological images for pathologists and students. The system and the interface are created in a manner whereby both pathologists/staff and users can handle the system without any hustle. For instance, the system allows the admin of this system to update and make amendments regarding the information present in the system. Apart from that, the system also provides Artificial intelligence assistance for reporters to identify suitable diagnostic tests that could be used for further diagnosis of the patient. This would reduce the usage of expensive equipment which would eventually save cost. The system will be built based on all user requirements that were mentioned previously in ().

The programming language that is used to design this system would be Java and Python. Both languages are used based on their suitability. These 2 languages are preferred to be used due to the fact that both of them are high-level programming languages that have great cross-platform support and extended standard library. Therefore, designing and modifying the system could be done effortlessly. Furthermore, the system could be updated swiftly if any errors are present in the system. Both user-defined and in-built functions will be utilized in designing the software. For instance, to upload a histopathology slide image into the system, the function/method **view()** is used. Besides that, the interface of the system will be designed using HTML.

In terms of security measures of the system, access controls are used to restrict access to patients' data to only authorized staff such as the system's admin. This is simply accomplished through authentication which includes using a password to access and modify the data present within the system. Furthermore, to maintain patients' privacy, only their ages and condition are displayed without including other personal information. In addition, encryption is also utilized to prevent unauthorized access to the system. According to specified standards, the encryption method that will be utilised is Triple Daya Encryption Standard (DES), which is the most often used symmetric algorithm. In addition, Firewalls which are network security devices will be employed to track down the incoming and outgoing network traffic in accordance with the stakeholders' security policy.

6.0 JUSTIFICATION OF DESIGN CHOICE

The website's operating system mainly uses white as its main theme color. This is because white emphasizes clarity and removes visual obstacles as well as clutters. The color neon blue is used since this color is usually associated with technology. Besides that, this color is also associated with reliability. Since this system will be commercialized. Therefore, gaining customers' trust is essential when it comes to its design. Next, the color black is used in the top and bottom frames since it gives a modern look and also has the capability to grab the user's attention.

This design has a drop-down menu where users may easily select what they would love to view. Next, Each case study present in the system provides summarised information regarding the histopathology slide. This would enable the users to grasp the information swiftly. In addition, there is also a comment and feedback section whereby, advanced scholars could comment on the information that is provided in order to improvise. The reference of each case study is also given below for the users to use for citation purposes and also to study more in detail regarding the case. Apart from that, the Pathonetics OS is also designed by including many pictures. This is because our brain is naturally designed to perceive everything visually rather than text. Therefore, using more graphics is useful in conveying concepts.
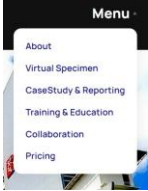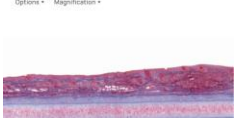
Most of the pathology informatics website does not provide an opportunity for other to collaborate with them. However, PathoNetics differs from the other informatics pathology system. This is because it also has forums for everyone to ask and discuss topics that are related to informatics pathology. Besides that, users may also contact experts to gain a better understanding. For instance, users may directly email researchers or pathologists to understand well on a particular disease condition. Apart from that, PathoNetics also encourages other researchers to conduct research based on the case studies that are present in the PathoNetics database. This is done to not only promote pathology partnership projects but also to include various findings regarding diseased tissues.

7.0 CONCLUSION

PathoNectics is a powerful pathology informatics system that provides various functions ranging from slide analysis, case studies, AI simulation training and many more. It serves a vision of transforming the pathology field through the advancement of technology and a mission of empowering those in the scientific community with artificial intelligence tools and informatics systems to obtain accurate information. This newly designed system is and will be able to provide enhanced clinical decision-making abilities leading to an overall improvement in patient care. PathoNectics paves the future for efficient pathological data with reduced amounts of errors and faster time for laboratory results. The development of new and unique features, interactive learning tools and AI-stimulated clinical training, in PathoNecticss, makes it an exceptional and revolutionary informatics system. The implementation of PathoNecticss benefits the healthcare sector and the patients by improving workflow, efficiency, accuracy and productivity. Ultimately, PathoNectics is a cutting-edge technology aiming to improve the management of pathology data by incorporating artificial intelligence (AI).

APPENDIX

Components for the PathoNetics website with examples to aid the description/ justification of the system design. The website link: https://pathonetics.framer.website/

Components	Description	Example
Navigation	Menu bar to access the site's contents easily	
	Link to official websites	
	Logo navigates from any page to the homepage	
Interactive tools	Virtual slides with tools	
	Vr case simulations for training/practice	
Interactive Learning	Quizzes/Online exams Conferences/Workshops Link to relevant article/publications	
Case Study & Reporting	Complete report of case study including clinical history, final diagnosis & discussion along with references	
	Comment/Feedback section on reporting	
Collaboration	Discussion forum for pathologist Collaborative research work for pathologist all over the world	

Website Design Flow

*** Click on the menu box to access all components & you may click on the Logo at the top side to get back to the homepage from any interface.***

1. Homepage
   - About us (about page)
   - Vision
   - Mision
2. Specimen
   - Cell & Tissue (Navigates to the virtual slide box of different types of tissue)
     (click on cartilage & Bone, it will navigate to 3 types of cartilage)
     (click on elastic cartilage)
     (elastic cartilage can be viewed with description)
   - Organ Systems
3. Case Study
   - Case of the month (navigates to list of cases, click on May 2023 case)
     (Navigates to the reporting page)
     (also has comments/feedback part)
   - Case by patient history
   - Case by diagnosis
4. Training & Education
   - Image Analysis & Computer Vision
   - Future Developments
   - Resources & Tools
   - Interactive Learning Tools
   - Learning Opportunities
   - AI-Simulated Clinical Training (navigates to the page with 3 options)
     (click on virtual case simulations)
     (vr case simulation video will be played)
5. Collaboration
   - Our collaborators (can click on it & it will navigate to the official pages)
   - Community collaborators (3 types)
6. Pricing

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