INNOVPLUS CHALLENGE 2021

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CHALLENGE STATEMENT #05

1. Challenge Owner Index and Pseudonym

#05 – TAMS – Training and Assessment for Medical Simulation

2. Challenge Statement

We are a public hospital seeking a learning solution that leverage on current technology to allow greater interactive and immersive experiences to further improve the appreciation of anatomy and the effects of 'surgery'. It can be structured to teach residents, junior consultants, and medical students not only common and less complex conditions, but also rare and complex diseases. It should also allow repetitive and deliberate practice, with embedded feedback and assessment components that are cornerstones of acquiring clinical expertise in a cost effective and sustainable manner.

3. About the Challenge Owner Organisation

TAMS is a public hospital in Singapore. It provides affordable specialist care for patients, training for doctors and other healthcare professionals, and conducts research to bring better care to its patients. Playing the role of an Academic Medical Centre, the convergence of clinical care, education and research enables us to pursue innovations to deliver better and more accessible care to our patients. Beyond hospital walls, we have taken strides to build a strong care network with our partners, to enable our population to receive the right care close to their homes.

4. Define the Challenge

The current methodology in medical education to teach human anatomy is via lectures with 2D pictorial slides and recorded surgical videos. Yet, recent studies have shown that this passive learning is inferior to active learning, especially when teaching anatomy *[Freeman S, Eddy SL, McDonough M, Smith MK, Okoroafor N, Jordt H et al (2014) Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci 111(23):8410–8415].*

The gold standard in anatomical education is human dissection, allowing free exploration of structures in vivo while also simulating surgical technique. However, the difficulty in acquiring, storing, and providing these specimens to residents, junior consultants, and medical students limits their usefulness, rendering this methodology applicable only to senior surgical trainees. The challenges to cadaveric dissection include financial costs, time requirements, and limited cadaveric availability.

3D printed temporal bones are easier to procure, but are still not widely available, and necessitate similar surgical equipment to drill and dissect. These also suffer from low anatomical fidelity, especially the internal structure of the mastoid bone. There is also lack of adequate labelling of anatomy, rendering them uninterpretable to the newcomer without senior support. Although virtual models have appeared in recent years, the tactile feedback is crude and expensive and their utility and adoption is low. Furthermore, the current virtual models would still require teaching academies to have powerful and expensive computer hardware to process the images. Such pre-requisites do limit implementation in many countries or in larger classrooms due to its cost and content scalability.

The current inadequacies faced by medical educators are explaining the complex anatomy structure and anomalies, which includes details such the middle and inner ear and the adjacent anatomical structures in a stepwise function, so as to be able to contextualize the illustrated components. The spatial orientation and relationships of various structures are crucial to the understanding and management of ear diseases. Ideally, it would be good for learners to be able to view the anatomical model that is not fixed in one place but could instead be manipulated by the learner. This would enhance factual and spatial knowledge retention, as the direct manipulation of the anatomical structures would be able to improve the fidelity of learners' internal representation of anatomical structures with regards to shape, location, and orientation.

Research has shown that humans retain more information and can better apply what they have learned after participating in 3D simulated exercises. *[Jaziar Radianti, Tim A. Majchrzak, Jennifer Fromm, Isabell Wohlgenannt. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda, Computers & Education. Volume 147, April 2020, 103778].* Three-dimensional object manipulation will allow learners to understand situations in depth, (normal anatomy, variants of normal and pathologies in this case) that they would otherwise rarely have contact with. One of the untapped resources TAMS has is the large databases of CT scans of past patient records that is available in the hospital's database. If these CT scans could be converted into 3D models allowing learners to manipulate and visualize structures to understand relationships, and anatomical details in a way that is impossible with even the most accurate diagram, model or textbook. This is where we see the unrealized potential application of immersive technology and the CT Scan could be explored.

- Currently, high-fidelity, manipulable three-dimensional models of the middle and inner ears (or other human anatomical parts) are not readily available.
- The technology used for converting CT scan images to 3D models are also not widely available and not accurate.
- Software using such 3D models for medical training and assessment is non-existent.

5. Requirements

An innovative solution would be the technology that could convert CT Scan images efficiently and effectively into accurate 3D models which could be then used for medical training and assessment. In addition, if the anatomical models could be integrated with text references, such that the learner could select an anatomical structure, and a pop-up text block would appear that described the selected portion and outlined its functional role.

With this solution, we will be able to enable residents, junior consultants, and medical students to manipulate and visualize structures to understand relationships, and anatomical details not just for the middle and inner ears in a normal person, but also in pathological and diseased conditions. This could be further extended be applied for many different medical specialties.

The solution should therefore have the following features:

- Efficient methodology to convert CT scan images into 3D models - [Conversion done within hours if not minutes]
- Cost-effective in converting the CT scan images into 3D models - [Cost lower than manhour cost in designing the 3D models]
- Accuracy of the 3D model is critical - [95% detail similarity in comparison to a CT scan]

- Cost-effective in developing different surgical scenarios for training and assessment - [Cost lower than manhour cost in designing the scenarios]
- In-game assessment of surgical

The learning materials for the prototype would focus on what our ears look like deep inside. It is exceedingly difficult to study the middle and especially the inner ear as it is difficult to depict details inside the ear three-dimensionally and map the spatial relationships of the structures, as well as the details of the inner ear, much less teach them using current 2D pictorial slides. The challenge is further compounded when the different symptoms of ear anomalies must be described to a young resident or a junior consultant.

Furthermore, if the anatomical models could come with realistic conductance of sound waves from the tympanic membrane and ossicles into the cochlea allowing learners to overlay relevant physiology. Such visual-based simulations are important in allowing our learners to internalize and contextualize their learning.

6. Targeted Learners / Users

Assuming that the proof of concept is limited to ear, nose & throat (ENT) domain, there will be between 200-300 per annum in Singapore. Should the solution be scaled up to other medical faculties, the impact factor would be much larger.

Users includes:

1. Medical Students
2. Residents
3. Associate Consultants
4. Consultants
5. Nurses
6. Allied Health

7. Deliverables

The deliverable shall include:

- A complete set of hardware and software solution that allows the deployment of a 3D simulated training and assessment surgery kit depicting a topic in ENT.
- The software solution should include an assessment module with an assessment dashboard.

8. Measures of Success

We are looking for a solution that could assist in 3D spatial description of the intricate body anatomy. It would be ideal that the solution could be applied to different faculties in the hospital. Different sets of CT images can be used to develop different scenarios for surgical training for different medical specialization. The solution could be commercialized as a product for the medical training and education industry.