Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Invention)

(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: JAPE045

Project Title: Ward Wizard

Project Type: Invention

***To our best knowledge, there ~~are~~ / are no * similar works in the market*; (if there are,) related product links are as below:**

The enhancement our project made / the difference with related products are:

Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.

I. Background

In recent years, the Hong Kong medical system has been overwhelmed by the overflow of patients in the hospital, causing patients to receive inadequate care, such as having to wait for long hours just to get admitted, and if admitted, constrained to sleep in the hallways of the busy hospital. In 2019, even before the pandemic, the bed utilisation rate at some hospitals reached 124%, while the average was 109%. We have conducted an interview with over 10 frontline medical staff, inferring the following results:

1. Every interviewee has noticed the issue of the lack of hospital beds
2. Over half of the interviewees have reflected the issue of the poor bed management and negligence of patients
3. Certain interviewees have also pointed out that the key issue is originated from "management"

We have also conducted interviews with over 15 patients from hospitals in Hong Kong, where the most of them agreed on our viewpoint.

II. Objectives

1. A method to allocate beds to patients, to have more patients admitted in the long term, and to prompt staff to allocate beds. The bed allocation process was found to be one of the three bottlenecks in the patient's experience at the hospital, with an average 19.5 hours wait time. Hence, this issue is prominent
2. The system should prompt the staff to clean the empty beds, and remove patients
    a. Cleaning empty beds: this is another of the bottlenecks, often taking 15 - 45 minutes (depending on the type of patient that used the bed)
    b. Remove patients: the last bottleneck is the discharge of patients, averaging at 6 hours due to administrative tasks. More than half of the hospital staff interviewed also observed patients being neglected at their workplace

    By prompting the staff to complete these actions, the flow of patients can be smoother.
3. Include functions that can predict the future flow of patients (e.g. amount of patients predicted to be received), to allow hospital management to arrange beds
4. Create a virtual hospital to test the system, allowing the creators (us) to test its effectiveness and improve it
5. Include an easy to use interface. Minimal training requirements will allow the system to be implemented easier and faster

III. Methodology

The system uses new technologies such as artificial intelligence, neural networks, and regression.

IV. Design of Invention

- Instead of using a brute force search and constraints and penalty system as the allocation algorithm, we made use of artificial intelligence with a dense neural network to perform regression to perform the following (written in Python, with the matplotlib and tensorflow models):
    - By collecting the symptoms of the patient input (e.g. body temperature), his urgency and condition seriousness could be quantified to form a "score" on a designated scale, and a predicted number stay time could be generated. This is a completely new and original function
    - Using this information, the algorithm allocates the patient a bed based on what suits him best. The patient with the highest severity will receive the highest priority, vice versa. If there are no beds available, patients with the lowest score will be prompted to be removed.
      After the patient is removed, the bed is prompted to be cleaned.
- Also making use of technologies such as artificial intelligence, neural networks and regression, the future flow of patients (information such as amount of patients admitted in the future) could be predicted. This information can be presented in a graph and number format
- In order to facilitate testing of the system, a virtual hospital was created, with patient generation functions
- An application can be installed locally on a computer to access the interface, that has functions such as being able to input new patients, update the patient's information, a graphic displays of the beds availability, a searching system that allows staff to search for specific patients, and allows the use of barcode scanners to aid searching patients up, as well as barcode generation and printing functions to allow easy integration with other existing services. The interface was created with the PyGame module.
- Apart from the application installed locally on a computer, files used to store crucial information that needs to be available globally, such as the data regarding amount of beds filled, can be stored on a server, so it can be accessed anywhere with the correct setup

Fig. 9/10. Symptoms input page (left), and quantified condition urgency/severity with predicted stay time (right)

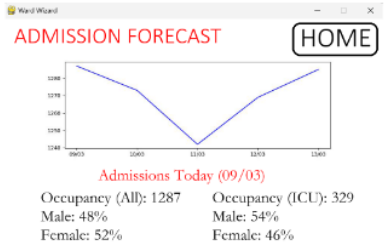
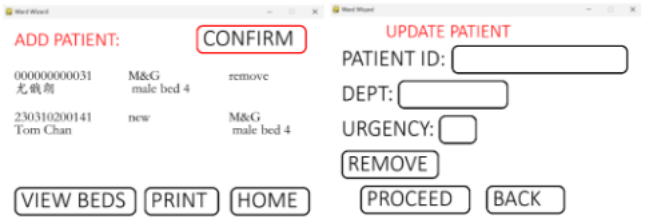


Fig. 11. Graph for Future patient flow prediction



(left) Fig. 12. Patient adding page, with option to print relevant barcode. The prompt to remove a patient is also seen.
(right) Fig. 13. Page to update patient information. The barcode scanner can be used in the "patient id" section to quickly search a patient.

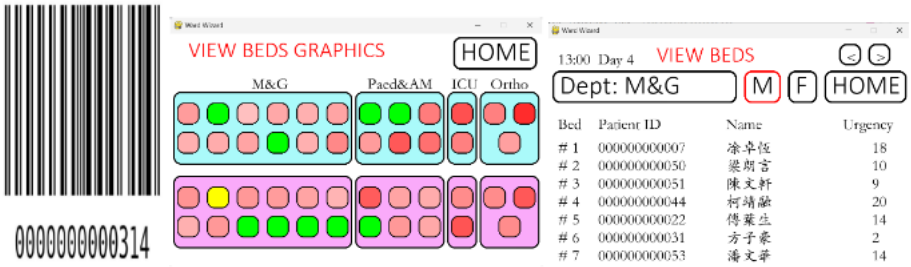


Fig. 14/15/16. A barcode generated (left), bed graphic map view (middle), list of patients with the simulated time and day (right)

V. Application / Market Need

This system will be highly useful in hospitals, and industry leaders have encouraged us to develop this project further. Apart from that, the Hospital Authority is constantly pushing the "Smart Hospital" initiative, which our current prototype can be integrated into, and supports that through the solution submission portal set by the Hospital Authority Innovation Lab that we visited as well. We firmly believe that this product will not only be useful for frontline hospital staff, but also the hospital management, and this same concept could be used in other scenarios, such as with air traffic controllers.

There are many hospital bed management softwares (HBMS) on the market. For example, the Rooman HBMS has basic functions that allow the admission and discharge of patients. Just last August (2022), the Hospital Authority trialled a hospital command centre, with clearer interfaces to allow hospital management to monitor the beds easily. The project that is most similar to ours is investigated by the UK National Health Service on improving bed allocation. They also adopted a similar approach to our first prototype, with a web interface and constraint-and-penalty based system, trialling the greedy algorithm and MCTS methods. Though, their investigation was not too successful, with parts of the prototype remaining incomplete, and the team at the lab reflected many issues that we faced with our first prototype, such as long running times. With completely original ideas, and a more all-rounded prototype, our product is better in this regard.

Furthermore, with so many hospital authorities having so much interest in developing bed allocation solutions, and with so much support in Hong Kong for these innovations, the future for these problems is a solution using cost effective technology, instead of spending billions on hospital expansions and hiring overseas hospital staff.

VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. *(Word limit: 300 words)*

VII. If your team will compete the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award. *(Word limit: 300 words)*

Our project, Ward Wizard is a system, through utilizing new and original ideas such as quantifying a patient's case's severity and urgency, aims to alleviate the hospital bed shortage, a serious social issue. Even before the pandemic, the bed utilization rate averages at 109%, and for some hospitals reach 124%. The UK National Health Service and HK Hospital Authority have taken interest into similar programs, and with so much support in Hong Kong for these innovations with the introduce of the "smart hospital" initiative and Hospital Authority Innovation Lab idea submission, the future for these problems is a solution using cost effective technology, instead of spending billions on hospital expansions and hiring overseas hospital staff. Also, this proves that our system is in high demand, and is definitely feasible if successfully developed. These types of allocation and resource management solutions are also required in the long run, hence this project has a high level of sustainability. In addition to that, being a computer system, the system is highly scalable, and the system can easily be adapted to different hospitals and settings. Hence, our project suits the criteria for being socially innovative perfectly.

VIII. Conclusion

In order to test the effectiveness of the allocation system, we conducted over 100 tests and collected over 40000 data points through the virtual hospital to identify the following:

1. Amount of patients admitted, tested with the algorithm turned on and off
2. Amount of patients rejected, also tested with the algorithm turned on and off

It is found that with the system on, 46.9% (3 d.p.) more patients were admitted, proving the allocation algorithm is effective in increasing the amount of patients admitted. Furthermore, the system eliminates patients from being rejected from a hospital, as in all 100+ tests, no patients were rejected when the system was turned on. Hence, this proves that with the system, the overall efficiency of a hospital has a significant increase.

To investigate whether the future patient flow predictions are accurate, the results predicted, and the numbers from a randomly selected real hospital were compared. As the virtual hospital and the real hospital were of different scales, z-score normalisation was performed on all the data points. The mean difference between the predicted and actual values is 0.134 (from -1.80 to 1.63, all accurate to 3 d.p.), further proving the predictions to be accurate.

☐ **Our project is developed based on previous project and the enhancement is below:**