Inno\textsuperscript{+} and InnoSpot

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Supervised by
Dr. Chui Chun Kit
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A. Background

The Tam Wing Fan Innovation Wing, an open environment to foster interdisciplinary innovations among HKU students and teachers in Engineering and Technology, began its operation in December 2020. Ever since its opening, it has served thousands of students by providing machines, facilities, financial and material resources to support students' projects and active learning.

To cope with the surging demand from users, this project will be dedicated to developing a smart management system that assists the daily operation and management of the Innovation Wing.

B. Problem Statements

1. Manual matching of on-duty trained staff to support equipment reservation is a repetitive and time-consuming task for staff.
2. Current operation using HKU Moodle for students to register for induction tour and equipment training does not fit the original purpose of Moodle.
3. Students have trouble finding staff on duty with the right skills or topics of interest to address their inquiry.
4. Managers of the Innovation Wing want to attain valuable insights for management based on analysis and mining.
5. Managers of Innovation Wing find it difficult to track the position of each of the tools to make sure the tools are in use and remained in a confined safe place.

C. Objectives

1. Inno+
   To improve the operational efficiency by managing the bookings and schedule of equipment and staff, as well as provide valuable insights to the management through analysis and mining on data collected.

2. InnoSpot
   To simplify the operational difficulties in querying the information, current or past position of tools inside the Innovation Wing, as well as alert the staffs whenever tools appeared in improper areas.
D. Scope
1. Inno+
The project will focus on designing a system with features and algorithms that can significantly improve the operations of the Innovation Wing. Therefore, the basics of the system like user registration, resetting the password, file/image storage, etc. will not be implemented in detail.

For booking of equipment, one equipment will be chosen from the walk-in and reservation category respectively as the focus, like 3D Printer (Walk-in) and waterjet cutting machine (Reservation).

For equipment training and induction tour, the quizzes required for each component will not be implemented in detail, these features will focus on registering a session with an available qualified staff.

2. InnoSpot
The system will be implemented on 2 mounted cameras on top of 2 tables in the Maker Space Area. The tools are confined with hammers, screwdrivers, jigsaw, power drills, and electronic screwdrivers only.

E. Deliverables
1. Inno+
A mobile-friendly web application that supports the operation and management of the Innovation Wing. The application has the following main features:

1) An integrated booking system that supports registration and reservation of equipment, booking of equipment training, induction tour, and technical consultation.
2) A centralized platform for displaying the schedule of equipment and staff, as well as individual staff profiles
3) A dashboard to display the statistics, results from analysis, and predictions from mining on the data collected by the system.

2. InnoSpot
A mobile-friendly web application that could track the position and view the record of each of the tools. The application has the following main features:

1) A live view of each of the cameras connected to the system, where each of the recognized objects on the camera will be contoured in a color box with confidence rate and danger level provided
2) History of appearance of each of the tools during opening hours
3) An alert message box that shows the alert message whenever a particularly interesting tool is recognized in a specified camera

F. Inno

1. Integrated Booking Center
   a. Equipment Registration/Reservation
      To allow eligible users to record usage of walk-in machines and reserve session(s) for machines. Data collected will be used for analysis.
   b. Equipment Training
      To allow eligible users to register for equipment training and complete the quiz to qualify the users with the corresponding skills.
   c. Induction Tour
      To allow eligible users to make reservations for induction tour and complete the quiz for general guidelines of the Innovation Wing.
   d. Technical consultation
      To allow eligible users to make reservations with academic staff, technicians, or tutors according to their schedule and their topics of interest.

2. Centralized Platform for Schedules and Staff Profiles
   a. Equipment and Staff Schedule
      To display all the scheduled sessions for each equipment and schedules of on-duty staff for the day.
   b. Staff Profiles
      To show the basic info, topics of interest, qualified skills, feedback score, schedule, etc. in individual profiles for each academic staff, tutor, and technician
G. Dashboard

1. Statistical Reporting
   a. Overall and new members
      The number of overall members and new members joined per month.
   b. Member distribution
      Categorize students by faculty, department, year of study, gender.
   c. Equipment support rate
      The percentage of tutors and technicians with the relevant skill to operate each equipment.
   d. Number of bookings completed or canceled
      The number of bookings completed or canceled for each equipment, equipment training, induction tour, and technical consultation per week/month/semester.
   e. Skill and rating of technicians and tutors
      Skills acquired by tutors and technicians and their rating received from students’ feedback. Classified by departments.
   f. Equipment training completed and trained students for each equipment
      The number of equipment training completed per week/month/semester and the number of trained students for each equipment.

2. Data Analysis
   a. Weekly Equipment Support Distribution of On-duty Staffs
      To analyze the number of on-duty tutors and technicians’ support on equipment for each session per week and generate alert messages when the support shortage emerges.
   b. Reservation rate to the support rate
      To analyze the utilization rate of equipment by comparing reservation rate and support rate

3. Data Mining
   a. User-based recommendation on equipment
      To suggest relevant equipment trainings to students, according to their department, interests, etc.
   b. Additional trained staff required to improve the equipment support rate
To improve the utilization rate of equipment

c. Peak usage hours for 3D printers
   To allocate tutors efficiently according to the result

d. Crowd control
   To predict the number of bookings or reservations to be made in the coming week

H. InnoSpot

1. Object Recognition and Tracking
   Object recognition is to identify the class a target object is associated with. Tracking is to follow the identified object over some time.

   a. Methodologies
      i. Machine learning
         By normalizing local histograms of the image gradients, image features such as edges, points, corners, etc. will be recognized to identify the interest points.

         The interest points and features will be compared with the distinct sets of characteristics of tools stored in libraries.

2. Accuracy and Differentiation
   a. Tool’s library creation
      Detailed features and definitions of tools in scope will be created as a library for a tailored-made system.

   b. Comparisons of different libraries
      Different online libraries that can recognize the tools will be employed for comparing the accuracy rate. The best one may be employed directly for use, instead of creating our library.

   c. Differentiation of tools
      i. Screwdrivers type
         Cross, pentagon, or type “I” screwdrivers shall be differentiated and recognized

      ii. Screwdrivers size
         The size of screwdrivers shall be recognized

3. Integration with Inno+
   a. Object details
i. Show the on-duty technicians who can help with the recognized tools
   ii. Show the precautions warnings

I. Software and Hardware Requirements

1. Software
   a. Front-end
      i. HTML, CSS
      ii. React
      iii. Typescript
   b. Back-end
      i. Spring Boot
      ii. Kotlin
   c. Database
      i. MySQL

2. Hardware
   a. Camera Specification
      Web camera equipped with FHD (1080p) video quality, supported long operation time.
## J. Schedule

### 1. Inno+

<table>
<thead>
<tr>
<th>Date</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>31/10/2021</td>
<td>• Designed the database schema and software architecture</td>
</tr>
<tr>
<td></td>
<td>• Completed the UI/UX design and prototyping</td>
</tr>
<tr>
<td></td>
<td>• Populated product backlog with epics and user stories</td>
</tr>
<tr>
<td></td>
<td>• Determined the MVP and iteration goals</td>
</tr>
<tr>
<td>30/11/2021</td>
<td>• Built CI/CD Pipeline</td>
</tr>
<tr>
<td></td>
<td>• Implemented the equipment registration/reservation feature</td>
</tr>
<tr>
<td></td>
<td>• Generated mock data for database and visualization</td>
</tr>
<tr>
<td>31/12/2021</td>
<td>• Implemented booking of equipment training and dashboard</td>
</tr>
<tr>
<td>23/01/2022</td>
<td>• Implemented booking of induction tour, and schedule of equipment and on-duty staff</td>
</tr>
<tr>
<td></td>
<td>• Intermediate Report</td>
</tr>
<tr>
<td></td>
<td>• Implemented dashboard and data analysis</td>
</tr>
<tr>
<td>28/02/2022</td>
<td>• Implemented staff profiles and booking of technical consultation</td>
</tr>
<tr>
<td></td>
<td>• Data mining – additional staff required, peak usage hours for 3D printers</td>
</tr>
<tr>
<td>31/03/2022</td>
<td>• Conducted user acceptance tests</td>
</tr>
<tr>
<td></td>
<td>• Data mining – crowd control</td>
</tr>
<tr>
<td>18/04/2022</td>
<td>• Final Report</td>
</tr>
</tbody>
</table>

### 2. InnoSpot

<table>
<thead>
<tr>
<th>Date</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>31/10/2021</td>
<td>• Feasibility Assessment</td>
</tr>
<tr>
<td></td>
<td>• Designed DB schema and software architecture</td>
</tr>
<tr>
<td></td>
<td>• Completed the UI/UX design and prototyping</td>
</tr>
<tr>
<td></td>
<td>• Determined the MVP and iteration goals</td>
</tr>
<tr>
<td>30/11/2021</td>
<td>• Machine Learning Algorithm Design</td>
</tr>
<tr>
<td></td>
<td>• Object Libraries comparisons</td>
</tr>
<tr>
<td></td>
<td>• Implemented Object Recognition for all tools set</td>
</tr>
<tr>
<td>31/12/2021</td>
<td>• Machine Learning Algorithm Implementation</td>
</tr>
<tr>
<td></td>
<td>• Implemented tailor-made tools library (50%)</td>
</tr>
<tr>
<td></td>
<td>• Data training (50%)</td>
</tr>
<tr>
<td>23/01/2022</td>
<td>• Implemented tailor-made tools library (100%)</td>
</tr>
<tr>
<td></td>
<td>• Data training (100%)</td>
</tr>
<tr>
<td></td>
<td>• Object differentiation (33%)</td>
</tr>
<tr>
<td></td>
<td>• Intermediate Report</td>
</tr>
<tr>
<td>28/02/2022</td>
<td>• Object differentiation (66%)</td>
</tr>
<tr>
<td></td>
<td>• Implemented integrated function with Inno+</td>
</tr>
<tr>
<td>31/03/2022</td>
<td>• Object differentiation (100%)</td>
</tr>
<tr>
<td></td>
<td>• Conducted User Acceptance Tests</td>
</tr>
<tr>
<td>18/04/2022</td>
<td>• Final Report</td>
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