EYES IN THE CONSTRUCTION SITE

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PROJECT 103 - APPLYING COMPUTER VISION IN CONSTRUCTION SAFETY MANAGEMENT
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INTRODUCTION

The construction sector significantly contributes to New Zealand's economic growth and is a high-risk industry. To reduce accidents, on-site supervision is one of the effective measures. The traditional manual supervision is challenged by the problems such as shortage of human resources, low efficiency and omission. In this regard, integrating **computer vision technology** with **construction safety management systems** has been identified as a robust solution that can compensate for the limitations above.

However, the challenges in applying theoretical research to practical work include insufficient training set on construction sites, inability to update the model iteratively according to new hazards, and lack of human-computer interaction applications. This research presents a computer vision-based safety monitoring system that engages safety management practitioners in the training data collection process. The system continuously updates the hazard information of the construction site to the training database, and professionals receive the detected results in real-time.

RESEARCH GOAL

The ultimate goal of the research is to promote the practical application of computer vision technology in building safety management. To achieve this goal, we aim to conduct our research from the perspectives of **computer vision model, software architecture and human-computer interaction.** Therefore, the major objectives of the project mainly focus on the following two aspects:

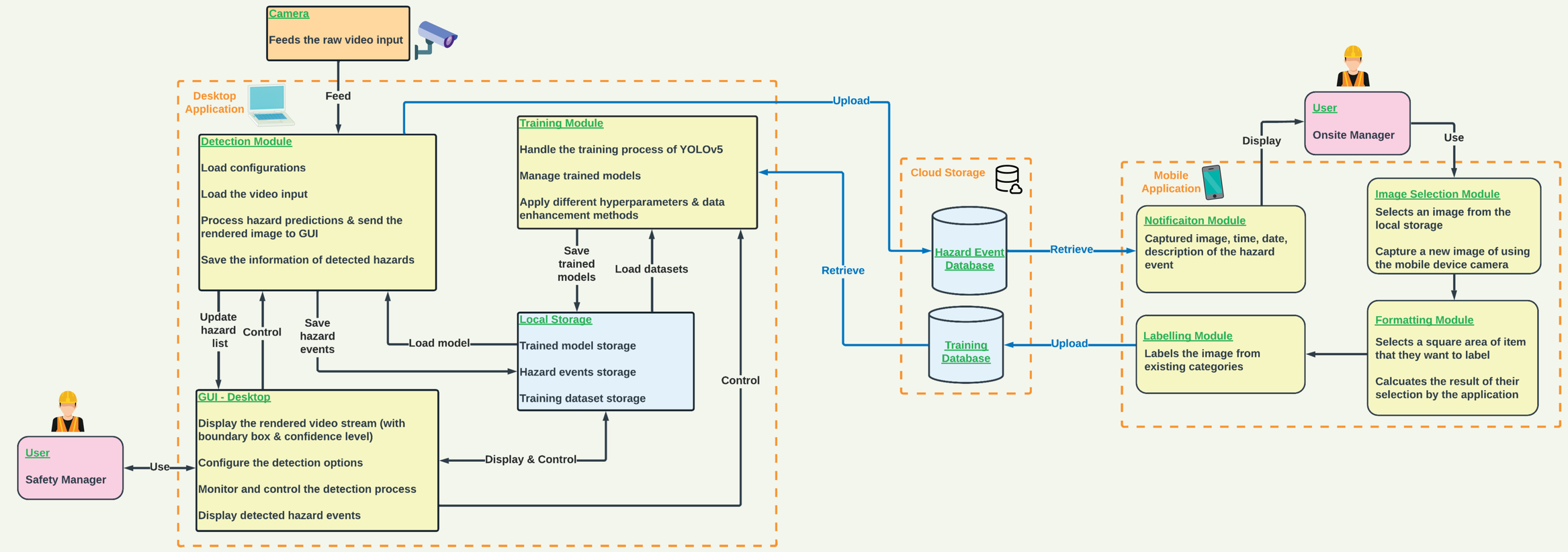
- ***Objective 1*** *- Establish a deep learning-based computer vision application to assist the model training and result evaluation process in the safety management system.*
- ***Objective 2*** *- Minimise the technical skills required for the training data customisation of a computer vision-based construction hazard recognition model*

SOLUTION

We propose a safety management system that employs **YOLOv5** as the object detection algorithm. The graphic user interface is developed using the **PyQt5** framework for the desk end and the native **Android** framework for the mobile end. The system uses a **SQL** database for data storage, where the interactions between the desk end and the front end applications are achieved via the interactions of the database. The main functions of the system consist:

- Allows users to take photos of hazard objects, add labels and upload them to the model training dataset through the mobile end.
- Notifies users of the latest detected hazards on both the desk and mobile ends in real-time with screenshots and descriptions.
- Switches the current object detection model from the pre-trained models and trains new models with the latest added training data on the desktop end.

SYSTEM DESIGN



TEST & RESULT

To achieve **Objective 1**, we evaluate the performance of the object detection model when new labels are constantly added to the training dataset. Three experiments test the model performance under **binary classification vs multi-classification**; the ground truth **contains only the new detection target's label vs all detection targets' labels** and **fixed pre-trained model vs iterative pre-trained model**. The tests demonstrate that the performance of the model's binary classification (all classes **0.8 mAP**) is much better than in multi-classification (all classes between **0.206 - 0.873 mAP**). The performance of each ground truth containing the label of all targets (all classes **0.795mAP**) is much higher than that of only the label of new targets(all classes **0.468mAP**). The performance is close to using the fixed pre-trained and iterative pre-trained models. We suggest using a binary classification model and running in parallel if the computation power is rich. Using multi-classification requires advanced labelling methods such as semi-supervised labelling.

For **Objective 2**, real-person user testing is conducted to evaluate the usability of the mobile application and measure the feasibility of the proposed solution of involving on-site workers in the computer vision training data collection process. Methods of **SUS** (System Usability Scale) and in-person **interviews** are used for post-test result analysis. The proposed solution has achieved reasonable usability from user testing with an average score of **77.5/100** in the SUS testing results with **13** users. **Ease of use** and **appropriate UI** design are two key achievements in usability. Potential limitations such as **error handling** and concept **understanding of labelling** are considered for improvements.

CONCLUSION

This research proposes a construction safety supervision system that promotes the practical usage of computer vision technology in the construction industry and contributes as follows:

- Proposed a method that can continuously accumulate training datasets in practical working scenarios
- Evaluated the performance of YOLOv5's object detection algorithm on a continuously growing training dataset
- Provide improvement suggestions based on experimental results

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