NIF083-1819
Wearable Sensors for Improving Occupational Health and Safety of Workers in the Forestry Industry

Executive Summary

This project has a primary goal of understanding the needs, challenges, and opportunities of using sensor-based remote hazard monitoring and developing a workwear embedded with such technology for harvesting and sawmilling operations in order to ensure the wellbeing of the workers.

The feasibility study suggests that the current proximate sensor based wearable devices are not suitable for the identified scenarios for reasons such as lack of required network infrastructure, extra hardware cost and potential accuracy due to signal interference. Therefore, the project team focused on developing an adaptable image-based object detection algorithm which can be easily implemented on a wide-range of devices (e.g. wearable smart devices on vest and helmet, centrally mounted cameras) to meet the project objectives.

Why we need to develop a sensing system for forestry workers?

Due to the hazardous working environments in the forestry sector, workers frequently face safety and health risks throughout the supply chain. Automated hazard monitoring systems based on sensor and short-range communication technologies, can acquire data, convert it to structured information, and immediately deliver these to the worker as an early warning for corrective action; considered one of the most promising methods to help manage these risks.

Approach

The Internet of Things (IoT) trend is well underway in Machine-to-Machine (M2M) communications and is poised to radically change the world's business environment. However, the availability of powerful inexpensive small sensing devices coupled with a communication network allow previously impractical applications to become possible, such as wearable sensor system for worker safety with real-time monitoring and warning.

UniSA, with industry partners N.F. McDonnell & Sons and OneFortyOne and funded by NIFPI, developed a solution adopted from currently available machine vision / object detection technology, the core of which is a machine learning model based on image data.

With respect to the future embeddable requirements, the project team decided to develop a mobile application using the standard on-device cameras with a proof of concept AI algorithm to test its suitability.

A DIY helmet mounted system (smart phone) was used to capture a video footage during the field trial in a work environment and the video was analysed frame by frame.

Four safety concerns / scenarios were identified as the priority of this project. 1. Human to Vehicle (Forklift and Truck) – indoor, 2. Human to Vehicle (Forklift and Truck) – outdoor, 3. Vehicle to Vehicle – indoor (less common) and 4. Vehicle to Vehicle – outdoor.

In the first stage, if object is detected then the box is drawn in the picture. The % is the threshold of the object boundary in relationship to the object type – for example, the software produces an initial estimate of 49% confident that within this area there could be a person. In the second stage the software used our trained algorithm to confirm the

detection. In the trial this resulted in a better than 90% accuracy. It could be expected that this could be improved with further testing.

The testing was able to cover all scenarios including both in-house and outdoor, ideal vs sub-optimal lighting condition, people to vehicle and vehicle to vehicle. This algorithm is capable of detecting three objects: trucks, forklifts and human in an accurate and efficient manner.

Project Highlights

- This project has successfully identified and assessed health and safety hazards of forestry operations based on literature, past accident data, interviews and observation/work-studies carried out in the field / identify the parameter requirements for hazard monitoring in forestry operations against readily available sensors.
- This development also aims to minimise development and implementation costs by carefully selecting low cost and easy to maintain components, and with a shared cost arrangement as part of the existing personal protection devices.
- Several successful measures (e.g. accuracy, adaptability, etc) and coverage scenarios emerged as the testing base for the proof-of-concept system with image processing accuracy of >90%.
- This project has successfully designed and delivered an image-based detection algorithm which can accurately detect vehicles and humans to alert for potential collisions.

Potential Benefits

- The proposed sensing system is expected to help prevent work-related injuries in forestry operations, in addition to help maintain the health and wellbeing of workers.
- It could reduce work-related injury expenses such as insurance claims, lost days and lost productivity.
- As an indirect impact, it could improve the productivity of a worker as they are alerted on the work environment to provide real-time safety situation-awareness that workers feel safer.
- It is expected that the mobile devices can be mounted on the vest, helmet and other personal wear. In addition, the application can also be easily modified for other embedded devices in the market.

What's Next?

Explore implementation and commercialisation options and the development of an implementation project to further confirm the applicability.

Future options

It was found that existing off-of-the-shelf algorithms to identify the proximity and direction of movement of a vehicle based on image processing techniques could be used in the future commercial development. If the camera is mounted in a relatively fixed position (e.g. on top of a forklift or helmet), it is possible to derive distances between two tracked objects through triangulation by calculating the angle of the ground surface. However, this can be complex as both objects may be moving and this information needs to be calculated rapidly, multiple times per second, and then linked to the potential impact algorithm to identify and alert of possible impacts.

Additional resources and efforts are required to move the project from POC to a minimum viable product for implementation including alters. Some required works include:

- Selection of hardware devices (e.g. centrally mounted devices vs wearable devices) will impact on the image detection algorithm training and tuning as well as alerting methods.

- Organisation-specific solution vs generic solution will impact on the development cycle and overall resource requirement.

What have we discovered and achieved?

- Image-based object detection can improve safety in the identified scenarios with high accuracy;

- An app can be installed on Android phones and tablet for organisations to trial the algorithm;

- Flexible options (decentralized vs centralized monitoring) are required to move the POC to the next stage.

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