Project Title:	S-Helmet: A Proactive Construction Safety Management System based on Real-time Localisation
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Objective

To provide a prototype of construction site management system that can monitor the real-time locations of workers and objects, and provide alarm when the workers are approaching to the dangerous areas.

Background

Construction site accidents account for nearly one-fifth of all industrial accidents in Hong Kong. It would be a good idea of a proactive safety management system which is able to continuously monitoring workers' locations and automatically issue warning alarms is available. This research describes a s-Helmet, which is a system for construction safety based on the real-time localisation technique. In s-Helmet, wireless tags are attached to the safety helmets of workers and moving objects to track their locations in real time. When a worker is moving near danger zones, the helmet will automatically issue an alarm to the workers as well as the construction site coordinators. The results of s-Helmet show that it has great potential to avoid construction accidents.

Methodology

- Analyzed the requirements for the Real-Time Localization System (RTLS) systems that can be regarded as practical RTLS for construction site management;
- Carried out a literature review on the existing works of in-door and out-door localisation techniques, especially those that can be utilized for construction site management;
- Designed the hardware localization module based on Nanotran ranging techniques;
- Designed and implemented information fusion algorithms in the s-Helmet to integrate ranging information with accelerometers and gyroscopes;
- Tested the Nantran ranging module and evaluate its accuracy, communication range, and reliability in different conditions including both outdoor and indoor environments.

Results and Findings

- Deploying a number of anchor nodes in the danger zones can be more useful to detect the relative distance from the s-Helmet users.
- Purely using the ranging information from the Nanotran nodes generally can only achieve high accuracy in an open and wide environment. This problem can be mitigated if the tag can collect some extra information from accelerometers, and gyroscopes.
- The deployment of anchor nodes is important to improve the accuracy. The anchor nodes could be placed higher in the construction sites such that they have direct line-of-sight to the tags.
- It is more appropriate to determine the localization without using the map matching technique in construction sites.

- The radio waves emitted by a tag is less than 100mw, which is less than 200mv~400mw in normal smartphones that have been commonly used so the radiation of the s-Helmet meets the safety requirement.

Recommendations

1. *Packet loss*: The packet loss rate of the s-Helmet is high in some conditions, especially in out-door environment. A better way is to find an approach to realize accurate localization in the presence of packet loss. The obvious solution is to leverage the information from sensors embedded in tags to help to localize itself without the assistance of anchors. The s-Helmet system was utilized by Kalman filter to improve the localization accuracy in the presence of ranging error.
2. *High localization error*: The localization error could increase to 2m or even higher in more complex environments with many blocks and NLOS effects. The NLOS effect can be alleviated if the anchor nodes can be partially replaced by nearby tags with known locations. This approach can increase the number of sensor nodes that can directly communicate with each other and therefore the NLOS effect can be alleviated.
3. *Capability to track swarm of objects*: The timing of the tags sending the UWB signals need to be scheduled to decrease the un-necessary transmissions and collisions. To avoid the possible collisions or multiple re-transmissions, the CSMA (Carrier Sense Multiple Access) and TDMA (Time-Division Multiple Access) accessing mode were combined as an efficient scheduling scheme.
4. *The power consumption*: More powerful battery, activity-aware power mechanism and energy-harvesting mechanism can be adopted.