SmartHelmets and BuildingCloud Technologies

AHMET ANIL SEZER AND
MARTIN RUDBERG

LINKÖPINGS UNIVERSITET
LULEÅ TEKNISKA UNIVERSITET
SMART BUILT ENVIRONMENT
UPPKOPPLAD BYGGPLATS

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Increasing safety and creating opportunities for productive construction sites

Ahmet Anil Sezer and Martin Rudberg

Making construction sites safe is one of the main priorities for NCC. In their project Sigfridsborgsskolan, new technologies were tested relying on three functions: fall and hit detection, localisation and DangerZones.

With support of technologies including Bluetooth beacons, a web-based collaboration application built around the IFC model and the digital twin concept (BuildingCloud) and IoT-sensors, the goal was to improve safety of construction sites, well-being of construction workers and their work environment. Site management personnel found these functions useful, especially DangerZones, for not solely improving safety of construction sites by avoiding workers to enter a DangerZone, but also using it as a planning tool to improve productivity of the construction site. This test project is a result of a collaboration between NCC, Scharc and Linköping University.

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1 The challenge

1.1 Background, aim and the need

The construction industry is one of the most dangerous industries in Sweden. According to the Arbetsmiljöverket, the construction industry has the second highest number of injuries (11 injuries/1000 employed) and has the highest number of deaths compared to other industries. It happens that construction personnel gets hit and falls on the ground, waiting for someone to localise and help them, which increases the risk of fatality. Moreover, some accidents can be avoided by informing construction site personnel of dangerous areas. By informing personnel properly about air quality and temperatures of different zones at the construction sites, long term negative effects on their health can be reduced as well. The aim with this test is to increase safety of construction site personnel by informing them of the DangerZones and introducing a warning system in case of a fall or hit.

The system being tested here relies on a combination of different technologies. Bluetooth beacons and SmartHelmets, an Internet of Things (IoT) device that collects and reports data to the digital twin, were used as well as a web-based collaboration application built around the IFC model and the digital twin concept called BuildingCloud. SmartHelmets and BuildingCloud were developed and provided by the Scharc Group. The system relies on three functions: (i) fall and hit detection, (ii) localisation and (iii) DangerZones. SmartHelmets detect falls and hits and send a warning to site management. When a SmartHelmet detects a fall or hit, an internal alarm is being triggered. The helmet of the person who fell or got hit starts blinking, vibrating and plays a buzzing sound. When the person does not press the "I'm OK" button in 30 seconds, the alarm becomes an external alarm.

When an external alarm is triggered, everyone close by wearing a SmartHelmet as well as the site manager get notified via their helmets blinking light, vibrating and making a buzzing sound. At the same time more information about the incident (what happened, who was involved and where did it happen) is sent as a message to their mobile phones. The localisation, aided by the interaction between SmartHelmets and Bluetooth beacons, allow site management to identify the location of the site personnel and therefore reduce the time for first aid. On BuildingCloud, site management can set DangerZones, meaning that all (or a group of) site personnel are forbidden to enter that zone.

For NCC, who initiated this test project, increasing safety of construction sites is one of the most important focus areas. In this test project, NCC and Scharc collaborate with support from Linköping University, for introducing a new technology to avoid

injuries and deaths at construction sites within the project “Uppkopplad byggplats” (Connected Construction Site).

1.2 The test project

NCC’s test project leader has been active in selecting tests, technologies, and construction site for the test. NCC in general identifies construction projects which are willing to be part of the test project as well as partners who are willing to develop systems and technologies. Scharc developed the system by using existing technologies and developing them further for the purpose of the test.

1.3 How were the required technologies found?

The technologies used in the test project included mainly Bluetooth beacons and SmartHelmets as hardware and BuildingCloud as web application. The SmartHelmets were designed, programmed and produced by Scharc. Scharc picked existing mass-produced components and designed their own Printed Circuit Board (PCB) and then the first 10 prototypes have been produced in Europe. During the tests, an agile workflow was used between NCC and Scharc with short tests and direct changes of the software which made sure that improvements could be carried out by Scharc continuously.

2 Information about the test

The tests were run at NCC’s project, Sigfridsborgsskolan in Nacka. NCC is building two schools in parallel for the municipality of Nacka for a total of 1500 students. The project is a part of a strategic partnering agreement which includes developing preschools, schools, and sport halls for the municipality.

Participants involved in the test project were:

- Main parties:
  - NCC, Scharc, Linköping University
- Key people/roles in the test:
  - NCC: Test project responsible, site manager, site supervisor and VDC developer
  - Scharc: Project owner, business developer and developing team.

3 Results from the test

3.1 The solution

In order to improve the safety of the construction sites, three functions were used. Fall and hit detection function detects when a site personnel falls or gets hit and then warns site management and other personnel. For the fall and hit detection, SmartHelmets are used which are IoT devices that collect and report data to the digital twin with a temperature sensor and a combination of accelerometer and gyroscope sensors for detecting a fall or hit (see Figure 1).

Figure 1. SmartHelmets and Bluetooth beacons

The localisation function supports the fall and hit detection function. Bluetooth beacons are installed in every room of the building which allows site personnel to see which room they currently are at (see Figure 2). It also allows site management to see where personnel are approximately. In that way, when personnel falls or gets hit, site management gets a warning and can quickly find out where the personnel is.

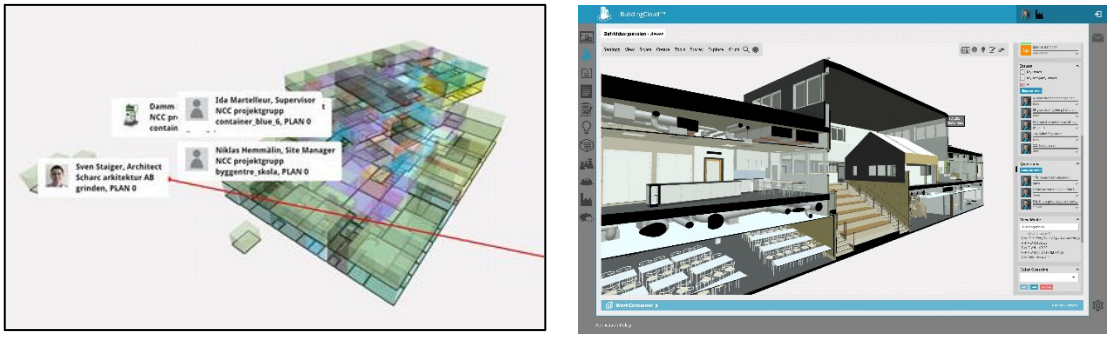

Figure 2. Beacons and location at site/in the model.

DangerZones function does not only reduce risks of immediate accidents but also improve health and safety of personnel in the long term. For the function, BuildingCloud is used where site management identifies certain areas as DangerZones (see Figure 3). These zones can be dangerous due to fire, high levels of

dust or noise. With support of the localisation function, personnel can also get a warning if they are approaching, or are in a DangerZone.

Figure 3. Setting a DangerZone on BuildingCloud

3.2 Effects and results

The fall and hit detection function was well-functioning and DangerZones were found useful by the site management team. Effects and results can be summarised as:

- The fall and hit detection test was successful, meaning that when a fall or hit was performed using the SmartHelmet, site management got notified that an incident had occurred and got informed about the involved person, time of the incident and the location of the helmet at that time.
- With use of SmartHelmets, site management gets a chance to observe if there is anyone left inside the construction site in case of an emergency evacuation, for instance fire.
- DangerZones were found useful and smart by the site management team. They are not only useful as DangerZones, protecting workers from dangerous areas and hazardous levels of noise and dust, but unlocks an opportunity to use DangerZones for productivity purposes, for instance as a planning tool to avoid crowds in certain areas under certain periods or planning logistics better on the site.
- With sensor data being connected to the BuildingCloud, establishment of DangerZones can be automated. For instance, a threshold can be set for dust and noise levels which are measured by sensors to establish automated DangerZones, warning workers in a specific area.

- Sensor data on BuildingCloud introduces other opportunities. Relying on temperature, dust and moist data, energy use can be optimised and systems such as heating can be automated. After the construction phase, the users can view noise levels in BuildingCloud to decide how they would like to decorate rooms to reduce/optimise noise levels.
- Localisation function can be used with machines and equipment, which will make it easier for construction workers to find what they are looking for on the construction sites.

3.3 Requirements and challenges

During the test project, weekly meetings with the test participants established a platform where their feedback was received regularly and Scharc could upgrade the technologies accordingly. The requirements and challenges in this test included:

- There were problems with the internet connection where SmartHelmets were losing connection and reconnecting. First the work phones were used for internet connection through a personal hotspot which did not function very well. Instead, separate Wi-Fi-hotspot devices were introduced which worked without trouble.
- For viewing the BuildingCloud on site, tablets were used.
- The SmartHelmets were relatively large and heavy. Therefore, they were tested in different places, on the belt and pockets. However, when placed on the belt and pocket, the gyroscope sensor detected several incorrect fall situations and warned site management which can be solved by adjusting the algorithms analysing the sensor data. According to the test participants, size of the SmartHelmet was a larger issue than the weight and their suggestions were to either use a smaller device on belts or to try the device on vests.
- There are many Bluetooth beacons assembled on the construction site and registered in BuildingCloud. Connecting each beacon to its room inside the BuildingCloud can be done by the site manager in the future. For the test they were assembled with double-sided tape on the ceiling framework, which was easy. However, alternative ways can be used in the future such as real estate owners keeping the beacons after the construction phase for further use.
- Registering people in the system takes time, it is worth to register workers who will be working at the construction site for some time, but it is too much effort for subcontractors who will spend only a week, or shorter, at the construction site. However, this can be solved by setting up a number of SmartHelmets for visitors and then borrowing these to subcontractors when they are on the construction sites.

4 Learnings and ”take aways”

Before and during tests, weekly meetings were held including personnel from NCC, Scharc and Linköping University. With these meetings, the upcoming tests were planned, feedback was provided regularly, and upgrades of technologies were made. For instance, the feedback on ergonomics of SmartHelmets led to improvements where devices were placed on the belt and pockets instead. During the tests, Scharc has been very active, visiting the construction site to test the localisation algorithms, monitor problems and fix them quickly. Moreover, an agile board was used where tasks were identified, assigned to participants, and were monitored. The agile board functioned very well for organising the tests and were used during the meetings.

Assessment of the tests were done via interviews with the site management team. This is because fact-based measures would be useless for the tests. The construction industry is one of the most dangerous industries and when accidents happen, they are often deadly, however accidents and incidents do not happen regularly on construction sites. This means measuring changes in number of accidents and incidents would not reflect the usefulness of the technologies tested here.

5 Summary and conclusions

5.1 Results

Results of the tests can be summarised as:

- The fall and hit detection function works very well on the construction helmets, however further improvements are required in case the devices are placed on other places such as belts and pockets
- DangerZones are useful for warning construction workers and avoiding them to enter certain areas on construction sites. These areas are not necessarily dangerous for the health and safety of the construction workers but they can be established by the site management team to improve productivity of the construction site
- Combination of localisation function, SmartHelmets and BuildingCloud are useful to monitor whether any workers are remaining in the building during an emergency situation, e.g. fire accidents
- There are opportunities to develop these technologies further including:
    - The SmartHelmets can be reduced in size and weight and can be placed in different places
    - Sensors measuring dust, noise and temperature can be used to create automated DangerZones to ensure health and wellbeing of the construction workers and to improve work environment

- Machines and equipment can be found easier on construction sites with support of localisation function, making the site more productive

5.2 Most important experiences

Having weekly meetings was one of the keys which facilitated the tests applied here. During these meetings, opinions of the end-users (in this case the site management team) could be heard as well as their suggestions for improvements. With Scharc and NCC being very ambitious, tests were planned and carried out very well, leading to an excellent collaboration. The tests were successful where participants reported that they would use for example DangerZones in their future projects and recommend to others as well.

5.3 How can the technology be implemented in other projects or companies?

The technology relies on (i) a web-based collaboration application built around the IFC model and the digital twin concept called BuildingCloud, (ii) Bluetooth beacons and (iii) SmartHelmets placed on helmets. In order to use the BuildingCloud, BIM models of the project have to exist. For the localisation function, Bluetooth beacons must be installed in the building. For the fall and hit detection function, special SmartHelmets are placed on the construction helmets. These technologies can easily be used and applied in other projects or companies. The only limitation is the phase of the project where these can be applied, because for Bluetooth beacons to be installed there needs to be at least a structure of the building.

5.4 Risks/pitfalls with the technology

There are no risks identified with the use of technology.

Contact

For more information about the test project, please contact:

- Martin Rudberg, Professor, Linköping University and academic responsible for NCC's test projects:
  - martin.rudberg@liu.se, 0734-14 10 22
- Claes Henschel, Digital Innovation Manager at NCC and test project responsible of NCC in the "Uppkopplad byggplats" project:
  - claes.henschel@ncc.se, 0790-788 196

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Smart Built Environment c/o IQ Samhällsbyggnad | Drottninggatan 33 | 111 51 STOCKHOLM | info@smartbuilt.se | 070-645 16 40 | www.smartbuilt.se