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INTERNET OF THINGS AS A COMPLEMENT TO INCREASE SAFETY[1]

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Safety evaluations made in the city Helsingborg indicate a decreased risk of being exposed to crime, but an increased feeling of unsafe. Damage in the form of scribbling (graffiti) is one of several indicators contributing to feeling unsafe. In this paper we investigate whether the use of Internet-of-things technology, where a sensor monitors a walking and cycling tunnel, makes it possible to reduce scribbling. The study shows a number of interesting results. When the sensor was installed, the public showed a great and positive interest. A short time after installation, the sensor was subjected to a qualified attack where heavy shocks were followed by an initiated way to determine if the sensor was damaged. A setting and tuning phase was used to empirically test different settings of the sensor to detect scribbling behavior. However, it became evident during the approximately 6-month long measurement period that we received many false alarms, which were, for example, that people took shelter in the tunnel in the rain and stood or walked slowly when using their mobile phone. During the measurement period, two scribbles occurred where the sensor detected one of them. We observe that the amount of scribbling has decreased significantly. The number of error reports on scribbling dropped from an average of 3.33 per month before the sensor was in place to 0.75 cases per month after the sensor was in place.

Keywords: smart cities; internet-of-things; safety; privacy.

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ИНТЕРНЕТ ВЕЩЕЙ: ТЕХНОЛОГИИ ИНТЕРНЕТА ДЛЯ УСИЛЕНИЯ БЕЗОПАСНОСТИ

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Результаты исследований в г. Хельсингборге свидетельствуют о низком уровне угрозы преступлений, но вместе с тем данные говорят об отсутствии чувства безопасности у населения. Причиняемый ущерб в виде надписей (граффити) является одним из факторов, усиливающих ощущение опасности. В исследовании выясняется, позволяет ли использование технологий интернета вещей (IoT) уменьшить число случаев причинения ущерба. С этой целью применялись интернет-технологии и датчик контроля пешеходного и велосипедного туннеля. Приведен ряд интересных результатов. Камера подвергалась атакам вандалов, выяснявших, работают ли датчики. Этапы установки и настройки были необходимы для эмпирического тестирования различных режимов камеры, чтобы обнаруживать авторов граффити. Однако по истечении примерно шестимесячного периода измерений стало очевидно множество ложных срабатываний, например, когда люди укрывались в туннеле от дождя и стояли или медленно шли, пользуясь мобильными телефонами. За период измерений появилось два граффити. Датчик обнаружил одно из этих изображений. Можно констатировать, что количество граффити значительно сократилось. Число сообщений об ошибках снизилось в среднем с 3.33 случаев в месяц без датчика до 0.75 после его установки.

Ключевые слова: умные города; интернет вещей; безопасность; конфиденциальность.

Background

According to the Art. 3 of the Universal declaration of human rights everyone has the right to live, to be free and to feel safe. However, our society needs to become safer (goal 16 of the 2030 Agenda[2]). The goal of the city of Helsingborg is that the city is perceived as safe and secure. This goal can be met if the city of Helsingborg, together with business, academia, residents and associations, can understand what make people feel unsafe and then develop solutions for a safer city, both in the short and long term.

The city of Helsingborg systematically collects information from activities within the city and from collaborating partners such as the police, housing and security companies. This information is compiled to create a common snapshot of what is happening in the City. The common snapshot is based on the method of "effektiv samordning för trygghet (EST)"[3]. EST is based on theory formation and research that, among other things, point out a number of indicators that affect safety. One of the indicators includes, for example, broken glass panes on buildings and cars, littering and scribbles. The common snapshot forms the basis for business planning and choice of measures to increase safety and is an important tool for the joint work by the city and the police.

Another important factor in charting the unsafety is to ask the residents what they think about their safety and vulnerability. The police security survey is sent annually to 3000 residents in the city of Helsingborg. The security survey for 2019 shows a marginal improvement in the residents' overall assessment of safety in the city. Figure 1 shows that the overall problem index for Helsingborg decreased to 2.37 in the 2019 survey compared to 2.40 in the 2018 survey. This means that the respondents collectively view the vulnerability and disorder in Helsingborg as a "not very obvious problem", according to the police's definitions. However, the improvement is marginal and efforts to increase the safety of local residents must continue to be one of the city's most important priorities. The survey mainly indicates that the residents perceive the safety of a late night and disturbances in traffic as the most "tangible problems" according to the police's definitions.

The city of Helsingborg has also conducted its own safety dialogues with residents. City-wide safety dialogues were conducted during 2017 and 2018 by the city's administration, the city-owned companies and collaborative partners such as police, rescue services and security companies. The purpose of the safety dialogues is to understand the needs of the residents, so it will be possible to create trust, trust and a shared commitment.

In total, the city of Helsingborg talked to about 800 local residents per year. More about Helsingborg's dialogue work can be read on the city's website, where the problems raised and what the city has resolved

[2]Transforming our world: the 2030 Agenda for sustainable development [Electronic resource]. URL: https://www.sustainabledevelopment.un.org/post2015/transformingourworld (date of access: 16.04.2020).
[3]Örebro Universitet [Electronic resource]. URL: https://www.oru.se/forskning/forskningsprojekt/fp/?rdb=p1401 (date of access: 16.04.2020).

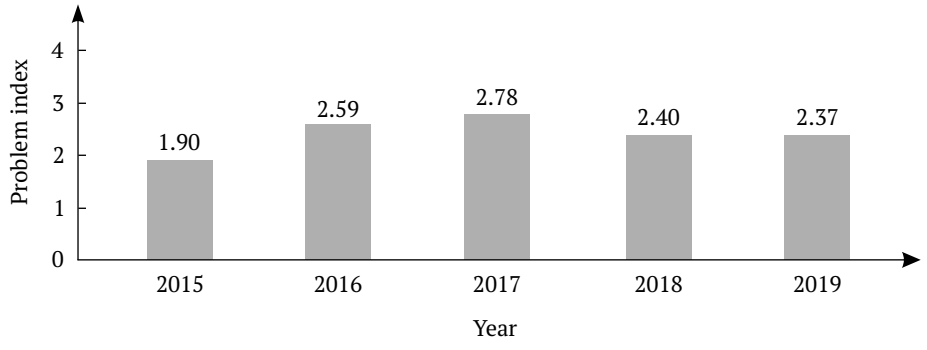

Fig. 1. Problem index in Helsingborg.
Source: Police

after the dialogue events have also been published. The city's dialogues, the police's survey and the city's work with location images form the basis for the joint crime prevention and safety-creating work in Helsingborg. Despite good efforts and analysis work as well as a reduced risk of being exposed to crime, the unsafety of the residents increases. Working with crime and disorder requires a definition of concepts such as safety, that is the risk of being exposed to crime and how the local resident perceives the risk. There is a connection between physical environment, crime and unsafety and it is about understanding the interaction between man and the physical environment. Thus, there is a need to investigate behaviors related to crime and in extension to the interaction between technology and man.

There have been previous works on making use of technology to detect graffiti. F. Tombari and others investigated the use of time-of-flight cameras for detecting graffiti, which is evaluated in a laboratory environment[4]. In Sydney, sensors have been tried to detect graffiti making in progress; however, the sensors do detect other smells but the vapor of graffiti[5]. Recently, Deutsche Bahn is exploring a combination of cameras and artificial intelligence to make it possible in the future to detect graffiti on trains automatically[6].

Goal

Our goal is to investigate if it is with the use of Citylab.com Internet-of-things (IoT) technology possible to detect damage in the form of scribbles and, by extension, be able to reduce the number of occasions a site in the city is subjected to damage and add information to Helsingborg city's work on joint mapping and causal analysis as a basis for a common situation snapshot.

Problem and method

We wanted to investigate whether IoT can be used as a complement to detecting scribbles. To conduct the survey, a sensor was installed that could use visual confirmation, filter out moving objects and classify them. The sensor was set up to detect if any object or objects were moving or standing still in groups or as single objects. By programming the sensor on the basis of this set of rules, a behavior resembling scribbling could be identified and recorded.

To evaluate the data from the sensor, there is a need to understand error reports, the choice of test site, the number of error reports at the selected test site and the selected technology are needed.

Error reports

A notification, error report, if scribbles are found is made, for example by residents, via a public application (app) "A better Helsingborg" or via the Helsingborg city website. An error report is sent to the city's Contact Center, which creates a case in a case management system, currently infracontrol online. The cases are then sent from infracontrol online to the contractor and the cases form the basis for the contractor's

[4]*Tombari F., Di Stefano L., Mattoccia S., Zanetti A.* Graffiti detection using a time-of-flight camera // Advanced concepts for intelligent vision systems. ACIVS 2008. Lecture Notes in computer science / Blanc-Talon J., Bourennane S., Philips W., Popescu D., Scheunders P. (eds). Berlin : Springer, 2008. P. 645–654.

[5]Gan V. A smell test for graffiti [Electronic resource]. URL: https://www.citylab.com/life/2015/05/a-smell-test-for-graffiti/393266/ (date of access: 16.04.2020).

[6]Hunting down graffiti with artificial intelligence, digital spirit [Electronic resource]. URL: https://digitalspirit.dbsystel.de/en/hunting-down-graffiti-with-artifical-intelligence/ (date of access: 16.04.2020).

remediation work. When the contractor is in place to clean, the contractor also removes scribbles discovered near the reported scribbles, these scribbles are not registered as new error notifications in the case management system.

The total number of error reports about scribbles reported in the city of Helsingborg during the period since 1 January 2017 to 31 December 2019 was 10159. Table 1 shows how the number of cases is distributed per year.

Table 1

Annual error reports in Helsingborg

Year	Number of cases
2017	4354
2018	3159
2019	2646
Sum	*10159*

Selection of test site

The chosen test site is the pedestrian and bicycle tunnel "Närlunda" located in the southern parts of Helsingborg. The tunnel has been subjected to repeated damage and scribbles which contribute to increased insecurity. The selected test site is identified by the Helsingborg citizens as a precarious place in security dialogues. The tunnel has previously been the subject of security initiatives implemented by the city of Helsingborg. However, despite these security efforts, several measures have been required to restore the tunnel to its original version.

Error reports at the test site

The number of error reports per day at the test site during the period since 1 January 2017 to 1 May 2019, before the installation of the sensor, is shown in the fig. 2.

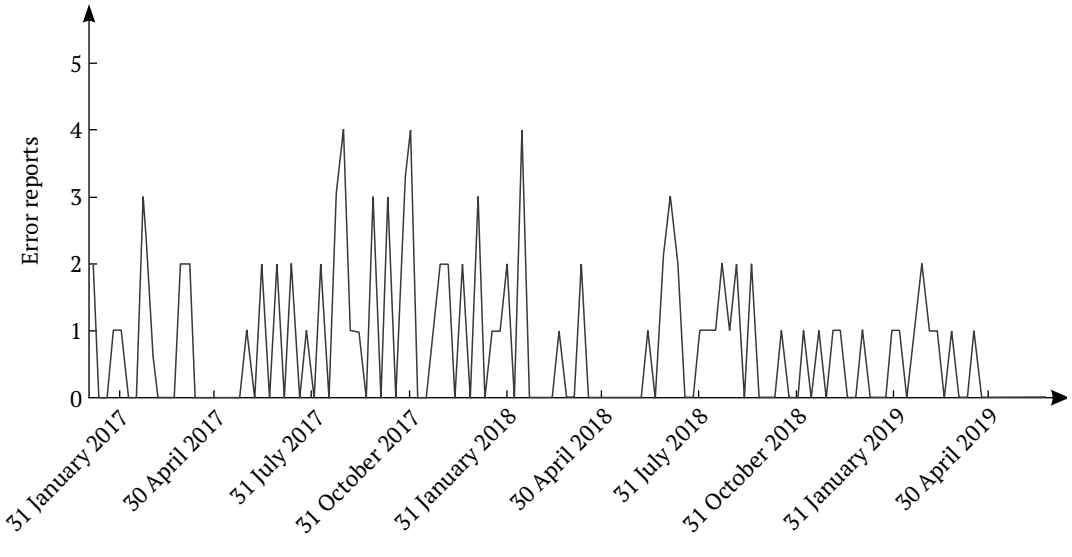

Fig. 2. Error reports at the test site during the period since 1 January 2017 to 1 May 2019

Selected technology – IoT

The selected IoT technology to detect if the tunnel is exposed to scribbles is connected sensor technology. To use this technology, access to electricity supply and network connection is required. The electricity supply was carried out by wiring in existing ducting in the tunnel roof and access to network access was carried out through a mobile router.

The sensor was programmed so to detect an object which remained within specific zones of the tunnel for a certain time. In order for the sensor to detect a behavior, it was required that an object is within these zones and had a behavior that corresponded to the settings, see fig. 3.

For a period of two weeks, the sensor was set and fine-tuned to detect a behavior similar to scribbling. The filtration was placed at a level where detection occurred when someone stayed in the tunnel for more than 90 seconds. The background for selecting a va-

lue for the time when one or more objects resides in the tunnel in it the order of magnitude was that during the period of the settings and the fine tuning we performed empirical tests where we saw that the mean value of time as classified objects stayed in the tunnel was less than 30 seconds. By setting a threshold higher than this, we were able to remove behavior that correctly met the conditions for an alarm but was not a scab incident.

The data generated by the sensor was stored locally in the sensor. In order to access saved data and thus be able to generate statistical data and confirm any detections, a secure login by an authorized person was required.

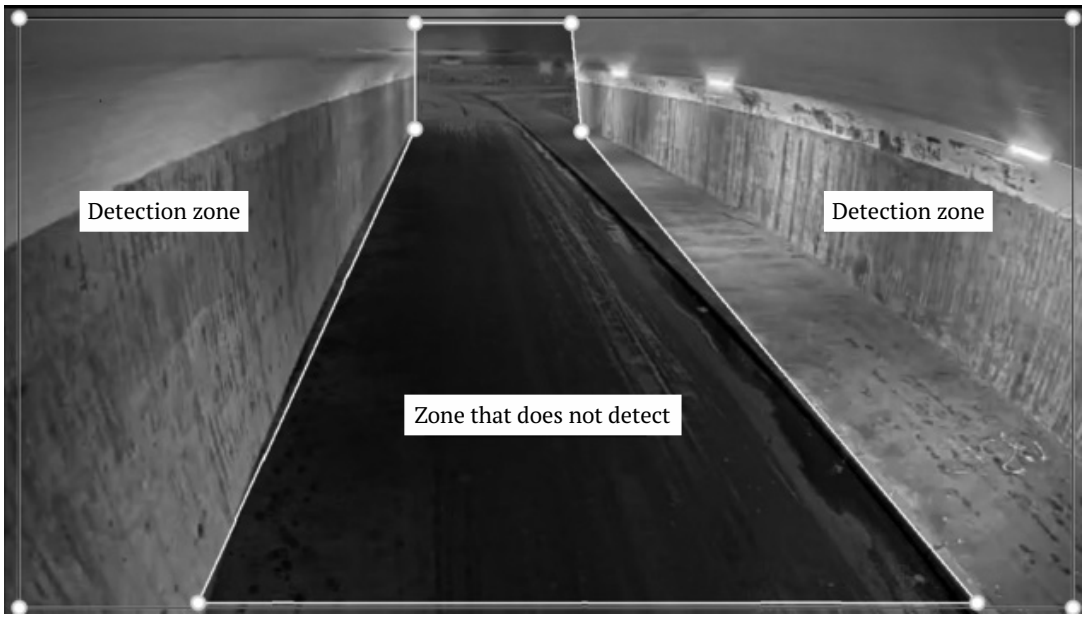

Fig. 3. Illustration of the sensors zones of detection and no-detection

Results

During the measurement period, since 11 June to 28 November 2019, an empirical study was conducted in which the sensor technology detected 307 cases of unwanted behavior. During the measurement period, 2 cases of scribbles occurred where one of the cases was not correctly detected.

The number of error reports from 1 January 2017 until 28 November 2019 was 103 for the test site. Of these 103 error reports, 97 occurred before the sensor technology was placed in tunnels, which is between 1 January 2017 and 1 May 2019, and 6 error reports occurred when the sensor technology was installed in the tunnel, that is between 1 May 2019 and 28 November 2019, see table 2. We compare the number of error reports before the sensor was installed with the number after installation. We note that the number of error reports has decreased from an average of 3.33 cases per month to an average of 0.75 cases per month.

Table 2

Number of error reports before the test period and after the test period

Time	Cases per month	All cases
1 January 2017 – 1 May 2019	3.33	97
1 May 2019 – 31 December 2019	0.75	6
Sum		*103*

Figure 4 shows the number of error reports at the test site per day from 1 January 2017 to the end of the measurement period 28 November 2019 (no error reports have been reported between 31 October 2019 and 28 November 2019). Figure 4 clearly shows how the number of error reports has drastically reduced after 1 May 2019, i. e. after the day when the sensor was installed. The high number of error reports around the time period 31 July 2019 in figure 4 can be correlated to the scribble that the sensor detected. Based on the study, we conclude that the installed sensor has had a good effect in reducing the amount of scribble in the tunnel. The sensor has also had an effect on the immediate area around the tunnel. After the sensor has been placed, only one error message has been received, around 31 October 2019.

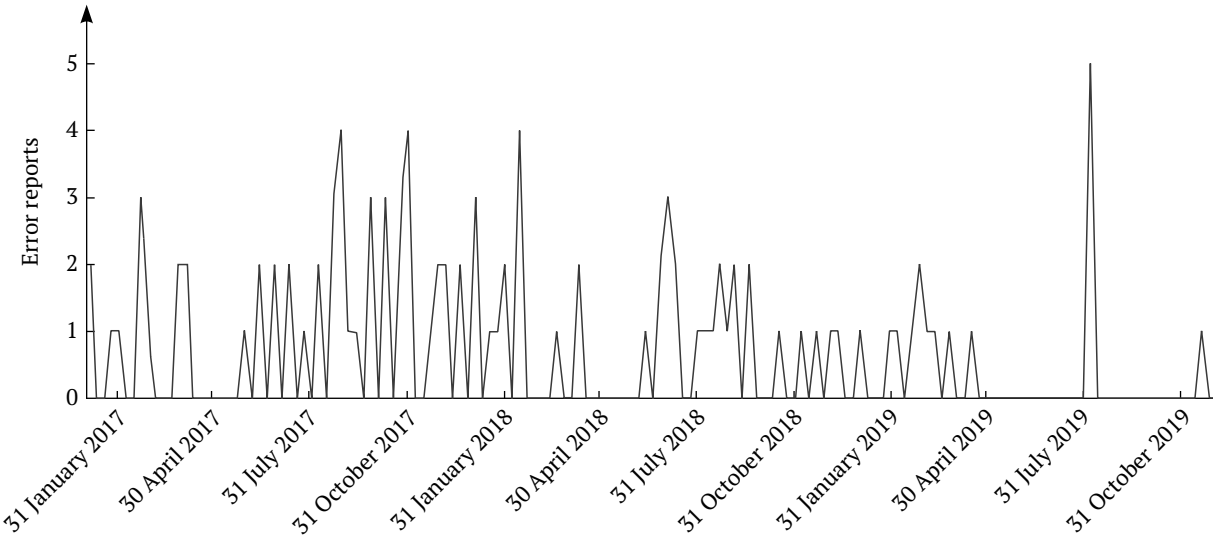

Fig. 4. Number of error reports at the test site from 1 January 2017 until 31 October 2019

Discussion

In the study IoT in the form of sensor technology was investigated as a complement to increase safety. The study shows that it is difficult to automatically detect a behavior like scribbling. The study shows many detections on behaviors that are not real scribbling, which may occur due to the cases when people seek protection for rain or people who walk slowly, such as people using a walker or who walk and look at their mobile phone.

During the installation of the sensor technology, many people stopped to discuss what was done and many expressed a positive opinion that something is being done to reduce scribbling. When the sensor was in place for about 2 weeks, it indicated a so-called shock detection. This means that the sensor has been subjected to severe violence or damage. When checking the sensor, it turned out that a group of 5 adolescents in the lower teens had struck the sensor. After repeatedly hitting the sensor, one of them produced a cell phone where it appeared that this person was filming the sensor for a short period of time after which the entire group quickly left the scene. In terms of experience, we have seen this before when people try to destroy monitoring equipment in some way and then find out if the sensors work or not. A functioning sensor leaks infrared light during darkness, which is invisible to the human eye. However, you can see it through another camera, for example, a mobile phone. In this case, we assume that the group saw that the sensor was still in operation, which is most likely the reason why they quickly moved away from the site. This incident was the only one that triggered a shock detection in the sensor. It is striking that young people of this age know that the systems work in this way.

The study shows that people change behavior when sensor technology is installed. The number of scribbling decreased dramatically from an average of 2 incidents and 3.3 error reports per month to 2 scribbling incidents in 6 months and 0.75 error reports per month.

We have seen a significant reduction in the number of scribbles and the number of error reports during the measurement period, but we cannot say for sure whether the reduction in scribbling will persist over a longer period. We have used error reports as a comparison, and it should be noted that since registration of the number of scribbling remedies is done through reports from the public, collaboration partners and the contractor, the actual number of scribes in Helsingborg is not necessarily the same as the number of registered scribes.

Future work could be to investigate:

1. Technology. The sensor technology used at the test site has limitations on both logic, hardware and reporting systems (ability to collect, filter and manage data). In order to be able to repeat the effort that has been evaluated, the system needs to be upgraded with another hardware that is able to handle filtering better but also supports artificial intelligence technology. This would enable, first and foremost, to refine the ability to detect unwanted behavior such as scribbling and other behavior such as people in groups staying in the tunnel during evenings and nights. The evaluation can also contribute to solutions for reducing graffiti in other places in the city.

2. Scale up. The study was conducted in a pedestrian and bicycle tunnel. It would be interesting to place sensor technology in several pedestrian and bicycle tunnels to obtain a larger data base.

3. Longer measurement period. The study showed a dramatic decrease in scribbles during the measurement period, but it would be interesting to investigate whether this decrease would persist over a longer period.

4. People's privace. A future study could investigate whether people feel that sensor technology is compromising their integrity.

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