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Livestock monitoring system using bluetooth technology

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Abstract. There is currently no inexpensive solution for monitoring theft of livestock. The cheapest way is to use a camera system. Whilst camera systems are able to capture theft attempts, in order to be truly effective it is necessary to permanently have a live operator available at the monitor to make evaluations. The aim was to therefore devise a system that would be used and that could identify the loss of an animal (or determine the specific animal that went missing). 'Bluetooth Beacons' were chosen after a detailed study of current technology. After closer inspection of this technology, we came to the conclusion that it is useful for this purpose with minimal cost for its application. This article would like to present concept of the method to monitoring livestock position.

Key words: ISM bands, Bluetooth Low Energy, iBacons, transmission, livestock.

INTRODUCTION

Today we can hardly manage without wireless technologies. Whether it is wireless transmission in surveillance systems, Wi-Fi networks, Bluetooth transmissions or various RC models, their transmissions are ubiquitous. All in all, they basically define the modern time and our civilization as such (Dong et al., 2013; Bisio et al., 2016).

As for the above mentioned technologies, ISM bands (industrial, scientific and medical) are mostly used for wireless transmissions. They are amply used in a variety of industrial transmissions. Officially, these bands should only be used for industrial, medical or scientific purposed. The Federal Communications Commission and the European Telecommunications Standards Institute established just the ISM bands as licence-free and given their licence-free usage they are also heavily preferred for commercial purposes (Tahir & Shah, 2008).

It is therefore favourable to use these modern technologies in the licence-free ISM bands to protect livestock in such a way that attempts at their theft are detected in time. And therefore is the aim of this article to present concept of the method to monitoring livestock position based on bluetooth technology. Although its purpose is clearly defined, following small modifications the resulting technology could also help in monitoring animal welfare (Kucera et al., 2015; Lopes & Carvalho, 2016).

MATERIALS AND METHODS

Following in-depth market research a technology conforming to exacting criteria for monitoring of livestock theft was selected. The Bluetooth technology was chosen as the technical basis for the final system for livestock monitoring (Lopes & Carvalho, 2016).

We went for the Bluetooth technology also because it uses a proprietary open standard for wireless communication connecting two and more electronic devices. The system design is based on Bluetooth BLE 4.0 version (Bluetooth Low Energy). BLE 4.0 runs in the ISM band 2.4 GHz (the same as Wi-Fi). It focuses on very low power consumption applications and it has been developed by companies associated in a group known as Bluetooth Special Interest Group (Bluetooth SIG) (Tahir & Shah, 2008; Elmasry, 2013; Bisio et al., 2016).

As a system development tool was selected a specific system based on a relatively new technology of Bluetooth SMART Beacons (iBeacons) see Fig. 1. iBeacons are used as electronic beacons for periodic transmitting information generally of any type. The principle is based on iBeacons transmitting data to smart phones, however this technology has another not yet discovered potential which can be fully utilized for the purposes of constructing the monitoring system to prevent theft of farm animals (Koppe et al., 2016; Park et al., 2016).

Figure 1. Different iBeacons types.

Of the different types of current iBeacons, EMBC01 type iBeacons which have several modes of transmission were chosen for our purposes (see Table 1). They can be set up so as to maximally save battery power while retaining sufficient reliability.

Table 1. The basic modes of transmission

Mode	Transmission range	Transmission interval	Battery lifetime
Sleep mode	-	-	> 7 years
ID Short Range	15 m	100 ms	1,5 months
ID Medium Range	30 m	500 ms	7,5 months
ID Long Range	75 m	1s	12,5 months

Basic EM Microelectronic extended and enhanced iBeacons technology by direct transmitting further information or data from iBeacons sensors and setting up individual custom application is made very easy. This feature was again in favour of our choice of this iBeacon type.

The unique parameters of this iBeacon were achieved due to two elements with an extremely low power and low supply voltage: EM9301 – Bluetooth Low Energy Controller with voltage supply from 0.8 V and EM6819 – 8bit Flash μController with DC-DC, ADC, OpAmp and EEPROM and voltage supply from 0.9 V. This iBeacon is also certified by FCC/IC/CE, it can be supplied by CR2032 Li 3V battery and is currently intended for temperatures ranging from – 20 to + 60 °C.

iBeacons basically only transmit UUID code (Universally Unique Identifier), not directly sending data that is displayed on the mobile phone. UUID (see Fig. 2) is a standard for identification of various "objects" in Linux and it is in hexadecimal format. It is mainly used for identification of different disk packs, by extension data provided by these packs (Garcia et al., 2016; Koppe et al., 2016).

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Figure 2. Example of UUID code.

The pattern of this communication between iBeacon and a mobile device is as follows (Fig. 3): iBeacon sends a UUID through the Bluetooth Low Energy technology to the mobile phone. Through its own connection to the network, the mobile phone sends the UUID code to the relevant Linux server, where it finds the required information and sends it back to the mobile device (Bisio et al., 2016).

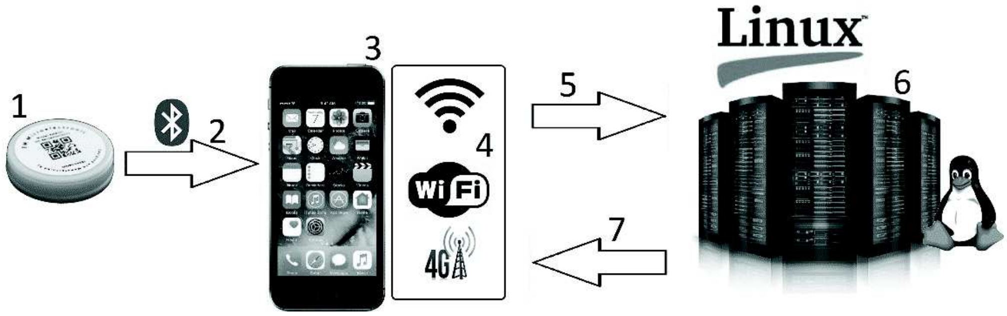

Figure 3. The pattern of information transmission initiated by iBeacon (1 – iBeacon; 2 – UUID transmission through BLE to mobile phone; 3 – mobile phone; 4 – form of mobile phone connection to the Internet; 5 – UUID transmission to Linux servers; 6 – Linux servers; 7 – transmission of required information to mobile phone).

Therefore their application potential is now to a large extent seen in Bluetooth marketing as a form of advertising, which distributes the advertising message through the Bluetooth technology. It allows for myriads of options of communication with mobile phone users, including a pocket guide to historical monuments or navigation around large exhibition centres. Given the fact that apart from direct communication with the mobile phone, it is also in touch with Bluetooth control units as seen in Fig. 4, the use of the technology is becoming increasingly variable (Tahir & Shah, 2008; Park et al., 2016).

Figure 4. Bluetooth control unit.

A small farm was chosen for the purpose of designing the system, with an adjoining pasture for cattle – see Fig. 5.

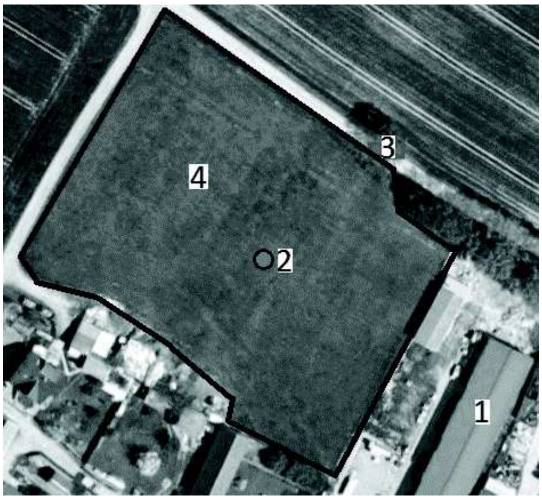

Figure 5. The chosen farm (1 – barn for housing cattle; 2 – location of centralized drinking troughs; 3 – fenced pastures; 4 – grazing area).

The pasture is 100 m long and 70 m wide. In our design of iBeacon EMBC01 setting we chose to use an option of ID Long Range mode sending data every single second. By doing that we reached the optimal range of transmission of up to 75 m, however with an effective transmission up to 50 m distance. The distance of this effective transmission is referred to as the declared distance, which is considered a distance over which the transmission should take place almost under any conditions. Thanks to the pasture size and possibility of using a Bluetooth control unit for the centralized water point in the installation, the number of Bluetooth units used was only two.

RESULTS AND DISCUSSION

Detection of an animal loss is based on a simple principle. When an iBeacon regularly sends data and the Bluetooth control unit receives regular messages of its presence from the given iBeacon, this indicates that things are in order and no alarm is launched. There was a time window determined during which an iBeacon must send a message at least once, and this was set to 5 seconds. On a standard basis it should report five times within this time, but an interference may occur thus this safeguard is set to prevent false alarms.

The designed system for livestock theft monitoring proved to be an ideal solution for inside spaces of the agricultural premises. The thick walls of the building shield wireless transmission and so it is possible to reliably identify whether an animal is inside or not.

A problem appeared when it came to outdoor grazing where animals can move beyond the determined area without raising alarm. However this distance is relatively small and theft would be identified in a short period of time. These issued are further worked on and an emphasis is now on the possibility of narrower specification (modification) of the receiving characteristic of the Bluetooth control unit to more accurately 'mark out' the guarded premises. In the future it is planned to follow-up research to apply on the aforementioned procedures.

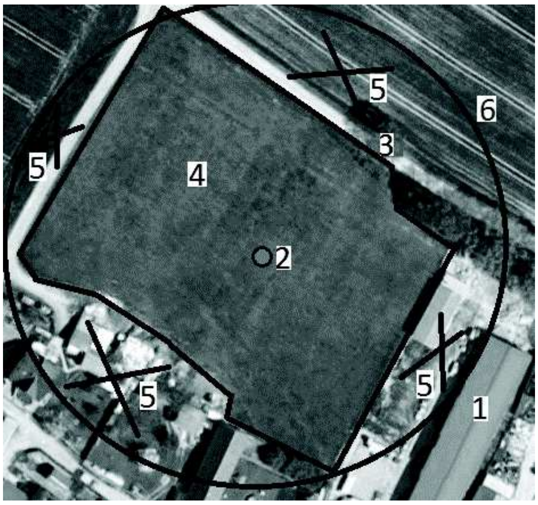

Figure 6. Chosen farm (1 – barn for housing cattle; 2 – location of centralized drinking troughs with outdoor Bluetooth control unit; 3 – pasture fencing; 4 – pasture; 5 – unmonitored area, 6 – range of iBeacons monitoring).

Although the use of RFID technology was initially considered, as described in the article on ‘A new asset tracking architecture integrating RFID, Bluetooth Low Energy tags and ad hoc smartphone applications’, it was given up for reasons associated with effectiveness of the detection method (Bisio et al., 2016).

As the selected method was not proven an optimal solution, the efforts to develop and modify the system of livestock monitoring must continue, since as claimed by the authors of the article ‘Livestock Low Power Monitoring System’, the development of systems to monitor livestock theft is a necessity today (Hartová & Hart, 2016; Lopes & Carvalho, 2016).

CONCLUSIONS

The aim of the investigation was to design a livestock monitoring system. The system design employed iBeacons technology which runs on Bluetooth Low Energy (BLE 4.0). This was complemented by Bluetooth control units intended to monitor the presence of iBeacons.

The designed system for livestock theft monitoring has been only partially successful so far. At present it is suitable for monitoring presence of animals inside buildings where their transmission is reliable. That means that if the monitored animal is inside the monitored building, its iBeacon sends data and the Bluetooth control unit smoothly receives it. However if the guarded animal leaves the monitored room, iBeacon transmission is attenuated through the walls and the Bluetooth unit stops receiving signals from the given iBeacon. After ten seconds the Bluetooth unit evaluates the alarm situation and through this obtains the information about one monitored animal being lost.

The use of this technology in outdoor areas yields only partial success at the present time. Although this technology can be partially used, there are a few dead spots in the design, where monitored animals can move being outside the area that we want to clearly restrict and monitor. Currently an emphasis is placed on the system modification to achieve monitoring of an exactly defined area without its spill-over to undesirable areas. Practice tests for proposed facilities are planned during the next follow-up research.

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