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Possibilities of monitoring cattle via GSM and A-GPS

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Abstract. Nowadays, people and things can be localized using GNSS (Global Navigation Satellite System) or GSM technology. Devices using Differential Global Positioning Systems may not be suitable for they computing and energy intensity. The GSM and A-GPS systems have certain limitations and disadvantages. They are different in accuracy, energy intensity and therefore they are suitable for different applications. Trackers can't be effectively used to locate animals, monitor their movements, and observe their behaviour. They can also be used to search for stolen pets and farm animals. Unguarded herds of cattle are often the target of thieves. For reasons of crime, localization was tested by devices using GSM and A-GPS technology. Specifically, the quality of these localization methods has been tested. Has been addressed above all, accuracy, reliability, speed and consistency of individual methods. In addition, further measurements were made. Localization has been tested in different well-defined environments. This makes it possible to judge the quality of individual localization technology and to suggest the best use of individual technologies and their link.

Key words: localization, tracking, cattle care.

INTRODUCTION

Currently, unguarded cattle herds are increasingly becoming the target of thieves and many breeders do not report these cases to the police, as it is difficult to track and find the perpetrator. Some breeders resort to posting rewards for information leading to the recovery of their stolen property. The complication is that monitoring cattle aggregation is not often done. Therefore, it is impossible to determine exactly when the cattle were lost. (Černá, 2000). It is therefore advisable to locate and monitor all cattle and this monitoring can be done using GNSS or GSM technology (Raizman et al., 2013). The tracking of these animals is not only for theft prevention but can also help to locate stray cattle (Bowling et al., 2008). Motion monitoring can help monitor the animal's health or observe and determine the rut period. To do this, the monitored animal must have a locator attached to it, preferably in the form of a collar. The device must be constructed such a way that it does not endanger the animal or is unpleasant in any way. The most appropriate device should be light weight, as to not put stress on the animal, and the battery life of the device should be considered a priority, as the changing or charging of the device would be impractical and very complicated in large herds (Sikka, 2004).

The Global Satellite Positioning System enables global positioning via satellites. It is used to determine the position and track the parameters of movement of animals and objects. The current positioning systems in use are the American GPS, Russian GLONASS, European Galileo and the Chinese BeiDou. The A-GPS system has been used in our research. The fast development in the use of GPS devices occurred after 2000 when the use of Selective Availability was discontinued allowing for civil and commercial use. Due to this, the GPS system became more accurate and usable in multiple applications. Either the user devices by means of code measurement, phase measurement, or Doppler measurement takes the position calculations. Code measurements are most often used (Bhatta, 2011).

In addition to GNSS, GSM mobile networks can be used for localization. Designed in 1982, the cellular network or mobile network is a telecommunication network designed for telephone calls, data transfer and other services. GSM is the most widely used standard. The network consists of mobile devices, Base Transceiver Station (BTS), Serving Mobile Location Center (SMLC), Gateway Mobile Location Center (GMLC). These networks work most often at frequencies from 300 MHz to 3 GHz. Thanks to the principles of the GSM network, it is possible to locate a mobile device when it is connected to the network. (Lee, 2010) The article does not deal with the design of any specific device. The article compares the GPS and GSM and their suitability for locating cattle in case of theft. The goal of the undertaken investigations was to determine, which technology is more suitable for cattle localization.

MATERIALS AND METHODS

Localization using GPS and mobile networks has been tested. Equipment used methods E-OTD (The Enhanced Observed Time Difference method) in GSM and GPRS mobile networks and OTDOA (Observed Time Difference of Arrival) method in UMTS networks for localization in mobile networks. E-OTD method is a terminal based method. (Dzulkifli et al., 2017). OTDOA method works on the same principle as the E-OTD method. The accuracy of localization by mobile networks depends on the density of BTS (Orlich, 2006).

Another method that was tested for determining the position was A-GPS. The devices use code measurements to determine the position. The code measurement principle use the distance between the receiver and the transmitter to determine the position. This method is used in most ordinary GPS receivers (Bensky, 2016). SBAS (Satellite Based Augmentation Systems) and GBAS (Ground Based Augmentation Systems) were not used. The accuracy displayed by the equipment is an estimate of accuracy in meters. A medium position error is displayed. The magnitude of the medium positional error is affected by the number of received signals, the location of the transmitters and the signal strength. For GPS, it is the constellation of satellites, the number of satellites used and the strength of the received signal. For these localization methods, the accuracy of localization depends on the environment in which the receiver is located (Ge, 2017). Measurements took place in environments where can be found stolen or stray cattle.

Navigation equipment PRA type LX series 1 was used. It is a mobile low-cost receiver with localization via GSM and A-GPS. It has a CPU Kirin 655 Octa-Core, a triple virtual antenna, a battery with a capacity of 3,000 mAh, for long life and works on

the android 7.0 platform. Is uses frequency 800 MHz, 900 MHz, 1,800 MHz, 1,900 MHz, 2,100 MHz and 2,600 MHz.

The measurement was done in three devices, from which the average value was made. Measurements took place in Central Bohemia Region in Czech Republic. Territory with coordinates 50° 3′0″ N, 14° 42′36″ E. The measurement took place during the day and on weekdays in 2018. It has always been recorded positioning time and positioning accuracy during measurement. Battery consumption was monitored, to avoid discharge during measurement however, without loss records. This battery monitoring was carried out only for measuring purposes. We expect reliably mobile signal coverage in Czech Republic. Mobile signal coverage is close to 100%.

- Forest

It is densely wooded environment in which trees hinder the view of the sky. Conifers and deciduous trees are higher than 5 m. We can assume a low BTS density and a weaker GPS signal. Therefore, may be less accurate and less reliable localization. Farmhouses are often found in the countryside, close to the forest. The cattle can stray into the forest.

- In trucks

The construction of the vehicle, by means of transport, does not allow for a sky view and the GPS signal is weak. The density of BTS depends on where the conveying medium moves. The conveying medium moved in the Central Bohemian Region. The stolen cattle can be transported by trucks.

- Countryside

The buildings are not more than 6 m high. The GPS reception conditions are good. There is good view of the sky. It is possible to assume great accuracy and reliability of GPS location. BTS density is low.

- Open landscape

This is an environment with an excellent view of the sky. Conditions for receiving GPS signals are ideal. The nearest building is located tens to hundreds of meters away. BTS density is low here.

- City

The city's environment is considered for cases of stray animals or the instance of a stolen animal transport vehicle. The city environment consists of dense building clusters where houses are over six meters high and the view of the sky is worsened. It is possible to assume a high density of BTS and a lower visibility of GPS satellites. The receivers were outside the buildings when measured.

- Farm buildings

The receivers were located inside buildings. There is no direct view of the sky. GPS signal is very weak. Measurements were carried out in farm buildings in the countryside.

RESULTS AND DISCUSSION

The GPS localization results are shown in Table 1. In environments with hindered views or no view of the sky, tracking accuracy is greatly worsened.

Accuracy is within hundreds of meters when localized by GSM. According to our results, we assume the accuracy depends on the density of BTS. The GSM localization results are shown in Table 2.

Localization by GSM appears to be highly inconsistent and less accurate. The advantage of the method is its reliability in an environment without a view of the sky. It does not matter if the receiver moves inside or outside the building. Localization is possible everywhere there is a mobile network signal. Localization usually takes tens of seconds. Another advantage of this method is the very low battery consumption. The device did not lose or disconnect from the signal of mobile networks during measurement. When measuring, it was always possible to determine the location.

Table 1. GPS measurement

Environment	Average accuracy (m)	Number of measurements
Forest	6.6	500
In trucks	45.5	500
Countryside	6.8	500
Open landscape	5.2	500
City	13.4	500
Farm buildings	47.5	500

Table 2. GSM measurement

Environment	Average accuracy (m)	Number of measurements
Forest	639.4	500
In trucks	863.6	500
Countryside	547.2	500
Open landscape	743.7	500
City	122.3	500
Farm buildings	384.2	500

The best accuracy was achieved in the city, 122.3 m and the worst was in the trucks 863.6 m. In low-density BTS environments as forest or open landscape, the accuracy of this method is hundreds of meters up to kilometre units. Accuracy was proportional to BTS density as expected. Therefore, the accuracy of GSM localization is not suitable for searching for stray or stolen cattle. It cannot be used to monitor cattle behavior and health. However, it is important in case of a GPS signal loss.

Localization with this technology is useful for monitoring wildlife migration, but only in areas where there is a mobile signal. The advantage may be the low cost of the GSM module over other used telemetry collars using different radio transmissions. In addition, all data is transmitted over the mobile network, so it is not necessary to approach the animal in any way and to move in the terrain.

GPS tracking is an accurate method. It is very accurate in ideal conditions with an excellent view of the sky, around 5 m. Localization accuracy is still good in the forest, 6.6 m. The least precision is in an environment with no sky view, as farm buildings 47.5 m and in trucks 45.5 m. This is enough accuracy for finding a stray or stolen cattle.

The reliability of this method is worse than the localization by mobile networks. Fisher et al. (2018) reported a small error rate of 8.2%, but they state that the error rate is not related to the type of environment, but we believe that reliability depends on the environment. Therefore, we recommend using GPS and GSM localization simultaneously. The combination of both technologies is most advantageous. GSM is more reliable, and GPS is more accurate. In monitoring wildlife movement, the loss of location information is not as critical as in the search for stolen cattle. Another disadvantage of this method is energy consumption.

The speed of A-GPS is surprisingly fast. Locating with A-GPS takes tens of seconds. Localization without A-GPS can take up to 12 minutes. Comparatively, this is a very long time and consumes a lot of the device's battery power.

Unlike the author Quaglietta (2012), we did not notice a significantly higher battery consumption in an environment with a worse view of the sky.

The device will send data over the mobile network network via SMS. Longer localization interval is enough to control cattle. For example, once a week. A shorter localization interval is required to locate stolen or stray cattle. Many researches have successfully used mobile networking to track animals (Dettki et al., 2004; Quaglietta et al., 2012).

However, both technologies do not have enough precision to monitor cattle behaviour. More information is needed to track the health and pregnancy of the cattle. For example feed intake, decrease efficiency, resting time, and physical activity a upravil bych na need to be monitored. Locators with GPS and GSM are not enough. Locators need to be supplemented with additional sensors. As confirmed by Hulbert & French (2001).

Further research could be about reducing energy consumption, as described by Ayatollahi et al. (2018). Locators could contain RFID tags to locate and track livestock, as the say Anu & Canessane (2017). Properly designed equipment does not affect cattle behaviour, as given by Manning et al. (2017) says. But it is necessary to test how the animal reacts to the device. It would also be possible to test other GNSS systems and integrate them.

CONCLUSIONS

It is advisable to use A-GPS for faster localization and less battery usage. The GPS itself is not suitable for the long-time of first position detection at start-up. The precision of localization by GMS is too inaccurate. It is a circle of hundreds of meters. This is not suitable for locating a stolen or stray cattle. The ideal tracker will be able to determine the location using both A-GPS and GSM. Use A-GPS for greater accuracy and use GSM for greater reliability. To check cattle, it is advisable to send data periodically, for example once a day or once a week. For localization of stolen or stray cattle is suitable to locate cattle on request. For example, in the form of an SMS alert. This form of alert is activated either when leaving the defined area where the device is to occur, or on demand from the system user in the form of an activation SMS sent to the device.

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