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Usage of multi-sensory MESH networks in monitoring the welfare of livestock

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Abstract. The trend of monitoring the welfare of livestock is continually developing at the moment. This monitoring leads to the optimization of the needs of livestock, which improves their final outputs. In terms of dairy cows, improvements in their living conditions may have a considerable impact on their productivity and the quality of their milk. Countless indicators such as temperature, humidity, how often they drink or eat, and many other parameters can be monitored. Specific measurements always depend on an initial hypothesis that is determined on the basis of specific problems. The main question still remains regarding how to measure selected variables, particularly how to transfer these outputs so that they can be easily processed. It is this issue that leads to the use of MASH multi-sensory networks.

Key words: MESH netwok, welfare, livestock, sensor networks, transmitter, IQRF, nod.

INTRODUCTION

One of the main goals of the research on livestock welfare is the area of simple data transfer. This always requires investigation supported by measurements which consists of the process of evaluation and gaining of the needed data. These measurements are used to evaluate external conditions which affect the welfare of livestock both directly and indirectly. Currently the most widespread are portable measuring instruments that are used for discontinuous measurement, or long-term measuring instruments located at points of interest for the long term, such as feeding points. This mainly involves wired sensor networks, though simple wireless transmissions are also used at times, the latter speeding up data collection and as for continual measuring they eliminate the risk of interruption of sensor network wired connection. It is mostly due to damage in the wired network that all communication through the used communication line fails, which may cause disconnection of the whole sensor network branch that normally contains many measuring elements. This triggers a critical failure of the whole measured sector leaving the overall measurement results incomplete and inaccurate. Of course there are also many risks and imperfections related to wireless networks that need to be considered. One of the most frequent risks of wireless transmission is natural interference or a limited range of wireless transmitters. Though being serious, these problems have their realistic solutions provided by an IQRF MESH network which can at least partially eliminate them. (Morisse et al., 1997; Milhaud, 2003; Mietzner et al., 2012; Behkami et al., 2017)

MATERIALS AND METHODS

To thoroughly understand the problems, it is needed to define the type of data paths to be subsequently compared. Because of monitoring the development of the situation in the field only continuous forms of monitoring will be evaluated, and in turn the data paths which can be used for this monitoring. Basic types of data transmission include simple direct line and bus connection. For wireless transmission it is a classic wireless transmission with repeaters and MESH type wireless transmission (Tahir & Shah, 2008; Mietzner et al., 2012).

Given the fact that contact monitoring of individual animals is not possible through a direct line and bus connection, these options do not fit the plan to create a system of livestock welfare monitoring with a focus on individual animals and their current state of welfare (Morisse et al., 1997; Milhaud, 2003; Behkami et al., 2017).

A classic wireless transmission using repeaters (see Fig. 1) will operate without wired connection with individual sensors, which in part reduces the problems relating to cable laying as well as final removing of the sensor network. Although it is used quite frequently, it includes a risk of loss of critical points (repeaters) and possibly even loss of data due to natural interference which may impact data paths. In this case it involves the communication between specific network nodes (detector – main unit). (Milhaud, 2003; Bradna & Malaťák, 2016; Behkami et al., 2017)

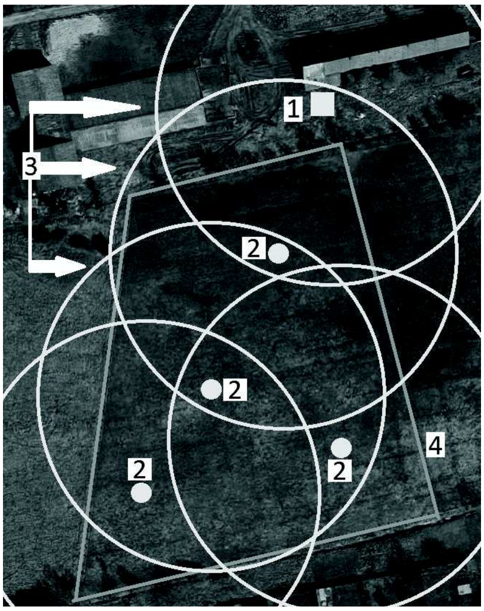

Figure 1. Design for wireless network distribution through stationary repeaters (1 – gateway; 2 – stationary repeater; 3 – wireless range, 4 – fence).

Regarding the classic wireless network we must not forget that each monitored entity has a transmitter on it, which transfers information through repeaters to the gateway – see Fig. 2. It is essential in this connection that repeaters must cover the whole monitored area. (Tahir & Shah, 2008; Dong et al., 2013).

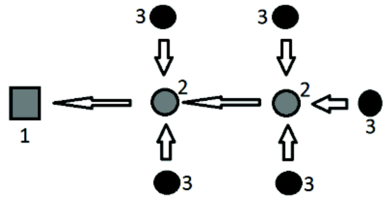

Figure 2. The transfer principle for a classic wireless network (1 – gateway; 2 – stationary repeater; 3 – transmitter).

MESH type wireless transmission (see Fig. 3) is a relatively new method which could find an extensive use right in the measurement of farm animal welfare. In this kind of transmission each transmitter also works as a repeater. This significantly reduces the loss of the needed information as the network points are mutually interchangeable. Therefore the failure of one network element does not create a situation where all communication would be disrupted, but only the one affected specific element of the sensor network will drop out. (Tahir & Shah, 2008; Yang et al., 2013)

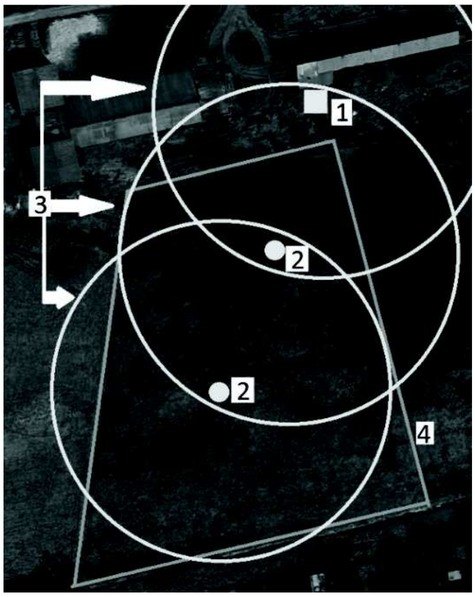

Figure 3. Design for a MESH wireless network distribution (1 – gateway; 2 – stationary repeater; 3 – wireless range, 4 – fence).

At first sight the classic wireless transmission through a MESH network is almost interchangeable. Both the options require stationary repeaters that send the information from transmitters to the gateway. However taking a closer look reveals that individual transmitters send their transferred data to all the other transmitters within their reach and these repeat their message – see Fig. 4. This enhances the network security and reduces the number of needed repeaters as compared to the classic wireless network. In this type of transmission repeaters do not need to cover the whole monitored space (Tahir & Shah, 2008; Dong et al., 2013).

An irregularly shaped pasture of 0.42 km^2 area was chosen to analyse the problems in question. It is a medium size pasture normally used for animal husbandry, where 19 measured points were set up. In order to compare the different types of connection a multi criteria scoring analysis of the options was chosen, considering important parameters that are essential to a sensor network installation and data transmission – see Table I (Mpitziopoulos et al., 2007; Tahir & Shah, 2008; Dong et al., 2013).

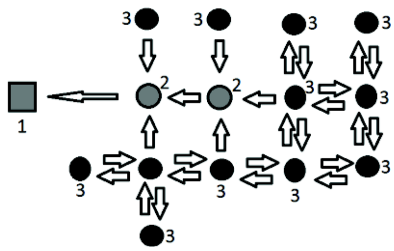

Figure 4. The transfer principle for a MESH wireless network (1 – gateway; 2 – stationary repeater; 3 – transmitter).

Table 1. Important parameters of multi criteria analyses of the options

Basic parameters	Detailed parameters
Safety	– Failure of one member
	– Interruption of routes
Instalation	– Sophistication of instalation
	– The difficulty of removal
Material	– The average price of material

Figure 5. IQRF elements.

The IQRF system was chosen (see Fig. 5) for implementation of MESH wireless transmissions, which enables transfer on ISM868 bands (industrial, scientific and medical). (Mietzner et al., 2012; Mpitziopoulos et al., 2007)

RESULTS AND DISCUSSION

Weight values for the multi criteria scoring analysis of the options were chosen based on price as the crucial criterion, followed by security and level of installation complexity. This is directly proportional to the current demands and pressure created by the private sector in the industry. This method was modified for the individual types of connection in the way that they were assigned a score for each item on a 100-point scale based on the set parameters. The resulting scores for both methods were then converted to percents and shown in Fig. 6.

It clearly follows from the multi criteria scoring analysis of the options that the optimal one for live operation is the wireless sensor network on the MESH basis. Out of a hundred percent that the individual types of data transfer could reach, the MESH type wireless transmissions were awarded 68.5% as opposed to classic wireless transmissions only awarded 31.5%.

MESH type sensor networks operate on different frequencies and based on different technologies. There exist different MESH type technologies (WLAN, Bluetooth, ZigBee, WiMAX and many more), however, given financial considerations, a low frequency IQRF technology is best-suited for the selected use.

As for the final MESH network application, a simple method of its nodes connection and basic configuration of transmission can be used. E.g. to monitor the temperature of an animal, specifically through the sensors attached to it, just a simple hardware connection will do – see Fig. 7.

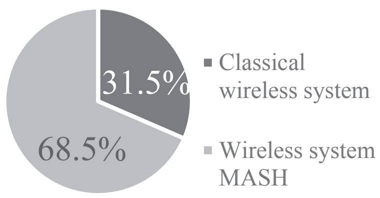

Figure 6. Results of multi criteria analysis of the options.

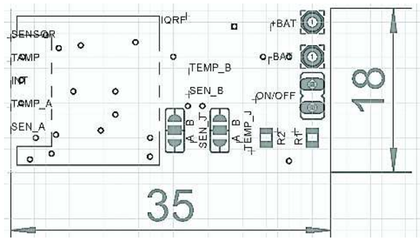

Figure 7. A printed circuit design for IQRF node connection for transmission of temperature.

As follows from the studies on 'Mitigating jamming attacks in wireless broadcast systems' and 'Coping with a Smart Jammer in Wireless Networks: A Stackelberg Game Approach', it is important for a wireless system to have alternative paths available, be variable and have replaceable key elements of the network. Also it is very important for the system to be able to assess the risks affecting it and adequately respond to them. A similar view was also taken by the authors of the articles 'Defending wireless sensor networks from jamming attacks' and 'Wireless Sensor Networks – A Security Perspective'. Therefore MESH networks are better suited for communication, where nodes function as repeaters as well (Mpitziopoulos et al., 2007; Tahir & Shah, 2008; Dong et al., 2013; Yang et al., 2013; Hart & Hartová, 2016).

CONCLUSIONS

It follows from the multi criteria scoring analysis of the options that wireless transmission through MESH networks is more advantageous than the classic wireless transmission through stationary repeaters. A MESH network comes out as more suitable as compared to classic wireless systems, specifically in the ratio of 68.5% to 31.5% respectively.

Based on this comparison the printed circuit design was subsequently developed for integrating an IQRF node for transmission of basic temperature data in order to monitor animal welfare while considering the monitoring of individual animals. More information can be derived from the monitoring of individual farm animals than from mass monitoring. A greater amount of variables are recorded that can be monitored and evaluated and decisions can be taken based on them as to which way to choose for moving forward and how to modify the present conditions to achieve higher yields.

Natural interference which may affect a wireless transmission occurs rather rarely, still it is important for wireless transmissions to be able to either identify such interference or replace the path of transfer. MESH systems do possess this feature and therefore are more secure in real life operation than standard wireless systems.

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