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Feasibility test of a positioning system to measure grazing behaviour of goat kids

To assess animal behaviour of goat kids on pasture, a real time positioning system, Ubisense 7000, was installed mobile and outdoors. One major goal of the study was to analyse time goat kids spent in functional areas like pasture, fodder hedges or hutch, the other goal was the feasibility of the positioning system regarding fixation at animals, accuracy and outdoor durability. Results show, that grazing periods happen even during the night, whereas fodder hedges were used only during daytime. Accuracy of the positioning concerning Euclidian geometry was around 15 cm, which is according manufacturer's data.

Keywords

Real-time-positioning system, goat kids, grazing behaviour

Abstract

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Observation and analysis of animal behaviour is still a time-consuming job despite technical tools such as video surveillance, activity sensors (pedometer) and innovative software. Thus, a great demand for automated procedures to localise position of animals kept indoors and outdoors is evident. For large-scale outdoor field trials satellite navigation is appropriate, which is already in use for livestock [1]. The localisation of animals within their housing environment is more difficult, shadowing metals of the barn equipment and the harsh environment and climate are often critical even for industrially proven methods. Research from Switzerland demonstrates [2], how much adaptation work is needed in order to monitor dairy cow behaviour with a radar-based tracking system (LPM) derived from sport and industry.

The positioning system studied, Ubisense 7000, has been used for the first time with goat kids and for the first time as an outdoor installation. The trial was conducted as part of another experiment on electronic animal identification, with special regard to assess duration of utilisation of fodder-hedges on pasture. Since this method of positioning animals did not apply under these conditions to date, the feasibility of this system was evaluated as well.

Technology, Animals and Methods

The experiment was performed with 60 goat kids of the breed German Improved Fawn. The animals were divided randomly into two groups of 30 goat kids each. Groups were homogeneous regarding age and immune status. The age of goat kids during experimental period was between seven and nine months.

The Ubisense Series 7000 real-time positioning system uses ultra-wideband (UWB, short UWB frequency range 6–8.5 GHz) to determine the position of active transponders called "tags". UWB signals can not penetrate metals or liquids, thus a sufficient number of sensors and optimal attachment is necessary, depending on environmental structures. Using ultra-wideband technology, wireless data exchange over short distances at high speeds with low power consumption is feasible. The Ubisense system utilises UWB frequency of the sensors to evaluate emitted signals by "tags" for positioning. "Tags" send signals upon request of sensors, then position is calculated using time difference TDoA (Time Difference of Arrival) as well as the determination of Angle of Arrival, abbreviated: AoA). In this method, determination is based on at least two base sensors whose distance to each other is known and the angle of entry of a transponder signal. In addition, signals are send on a straight line from a certain angle to the ground. The intersections of these lines are calculated by software as positions of the transponders ("tags"). The accuracy of positioning specified by the manufacturer is up to 15 cm. For accurate positioning at least two sensors are needed, but a complete cell-geometry of the Ubisense system consists of minimum 4 sensors. The control of the "tags" is done using a 2.4 GHz channel. "Tags" can be "switched off" individually. The communication among sensors uses an Ethernet interface and a network switch that supplies the sensors with the required operating voltage by PoE (Power over Ethernet). Using a timing cable between the sensors, the synchronising "master" sensor distributes an analogue timing signal as basis for TDOA calculations to all "slave" sensors connected. The software contains a so-called "Location

Engine Configuration" module for the integration of real-time location system in the network, definition of sensors and sensor cells, identification of "tags", configuration and calibration of sensors; the module "Site Manager" integrates floor plans in the positioning area by definition of persons, animals or objects and the definition and classification of specific areas or zones. In the module "map" events can be visualised, e.g. if a tag is crossing a virtual fence or line of certain area this will be recorded with time stamp for entry and exit in that zone. The "tags" we used in the study were named "Compact Ubitags", with dimensions of 38 mm x 39 mm x 16.5 mm and weight of approximately 25 g.

Experimental setup

Based on the manufacturer's recommendation, the sensors were placed approximately 4 m above ground, with a minimum distance to the nearest sensor of 10 m and a maximum distance of 50 m. For this purpose, sensors were attached to a tripod, as seen in **Figure 1**. For a given pasture/activity area of 3 500 m² 6 sensors were needed (see **Figure 2**)

The centre points of all sensors were determined using DGPS (Differential GPS with Real Time Kinematic, AgGPS 332, Trimble Navigation Ltd.). Measured elevation data and sensor positions (accuracy 2 cm) were written in the coordinate system of tracking software to enable a mutual calibration of sensors. As an additional calibration, seven fixed points in every measurement area, whose positions were measured by means of DGPS, were compared with "tag" positions of the software. Based on known coordinates automatic calibrations of the sensors could be performed by means of a software module. During the experimental period, the positions (calibration) were recalculated several times to identify any discrepancies.

The "tags" of the goat kids were fitted by a special harness. As part of some preliminary experiments, goat kids got used to the harness (**Figure 1**). Goat kids showed no signs of disturbance by the belt straps during the experimental period.

Figure 2 shows the plan of the experimental setup of an examined pasture with hedgerow, hutch, position of six sensors, network switch and the laboratory container, network cable and power supply.

During automatic recording of positions all 30 goat kids of a group were equipped with a harness, so that all goat kids could be recorded simultaneously. The groups were exposed to two different types of lining hedges and pastures.

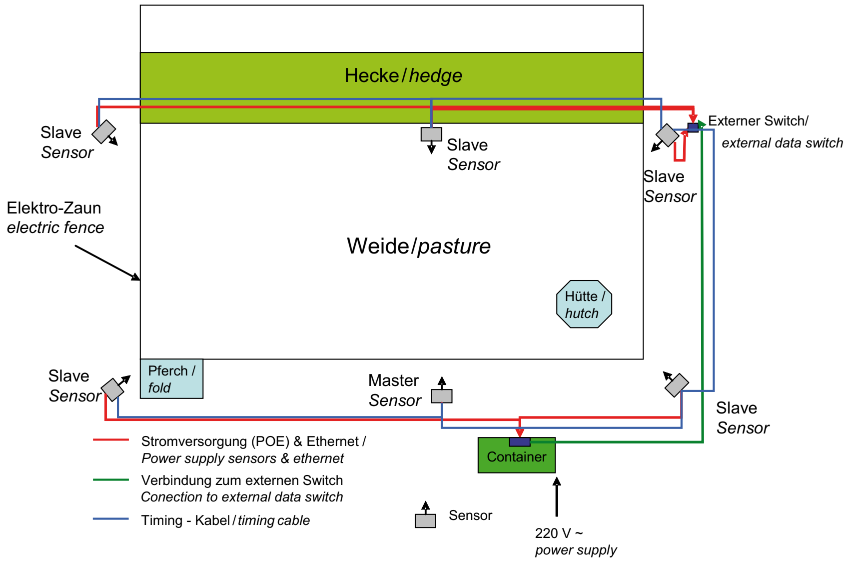
To give an answer to the question "how long do goat kids stay in the hedge?" several event zones were established. Software modules recorded animal movements as x, y, z-coordinates as well as event-induced as entry/exit data with time stamp for specific zones.

In addition to the tracking system, goat kids were observed using video cameras. In a subsequent analysis data were extracted from these videos to compare time duration in functional areas and rainy periods.

Fig. 1

Goat kids with chest belt and tags, sensor (with plastic cover) fixed at tripod in the background (Photo: Georg)

Fig. 2



Schematic view of experimental setup

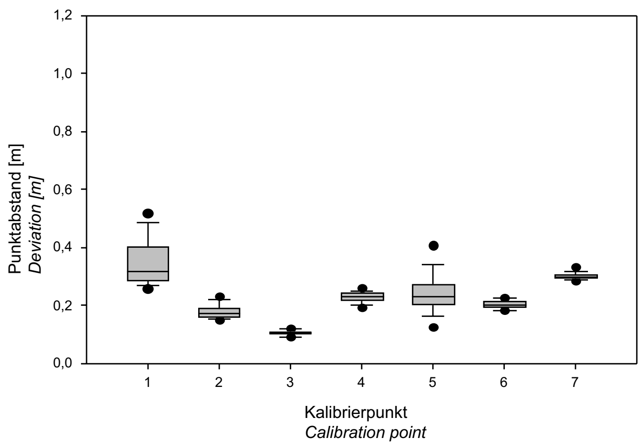
Results

For calibration purposes seven points were compared per plot both with tag position and with DGPS positions. **Figure 3** provides an example. The boxplots represent the Euclidean distance (2D) between the measured values of the Ubisense system and the DGPS coordinates.

Two values of calibration of August 19th were above the specified Ubisense accuracy of 0.15 m. Five values were much lower with an accuracy between 0.028 m and 0.081 m.

Figure 4 illustrates the geometrical position of the points on the experimental plot, wherein position of the master sensor was the equivalent to zero point of the coordinate system.

Fig. 3



Calbration (08/19/2010) plot of deviation in [m] (euclidian geometry 2D)

Since the data collection began at 8 a. m., the first measuring period lasted 16 hours (8 to 12 p. m.), the second 24 hours (0 to 12 p. m.) and the third 8 hours (0 to 8 a. m.).

Figure 5 shows the percentage of goat kids stay on the trial area GJH within the first two days after change of pasture and after the cutting off fodder-hedge.

It is noticeable that entry of goat kids into the fodder-hedge occurred only during daytime (5 a. m. to 8 p. m.). Individual feeding periods were clearly visible, maximum length of stay in the fodder-hedge could be up to 50 % per hour, but on average duration of stay is between 10 % and 20 %.

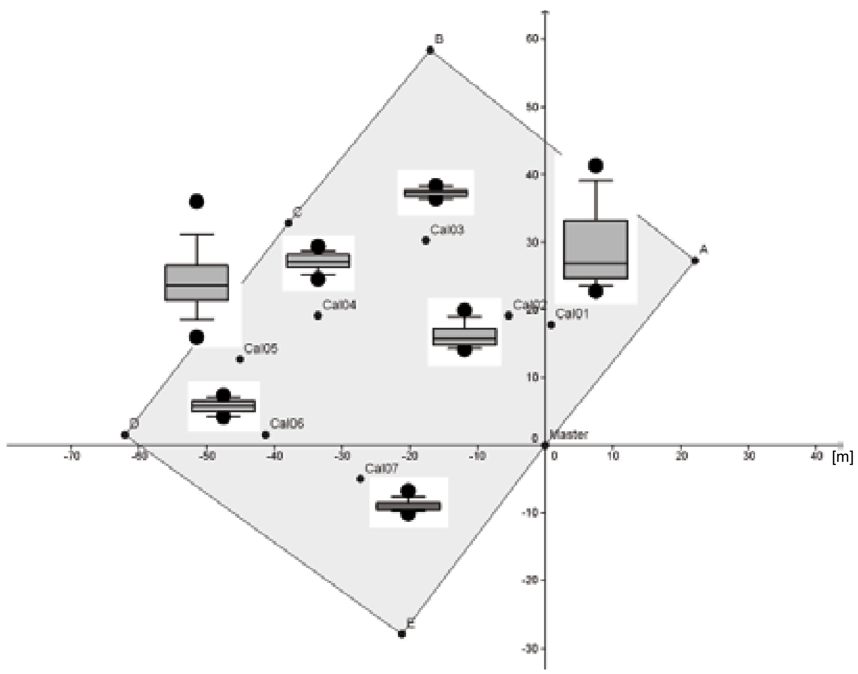
If goat kids were not registered in the fodder-hedge, they were mostly in pasture area during the day. During the night they were between 10 % and 50 % per hour in the pasture.

Preferred time to stay in the hutch was three out of four days in most cases between 8 p. m. and 5 a. m. except of 08/16/2010. On that day goat kids spent up to 60 % per hour in the hutch.

Conclusions

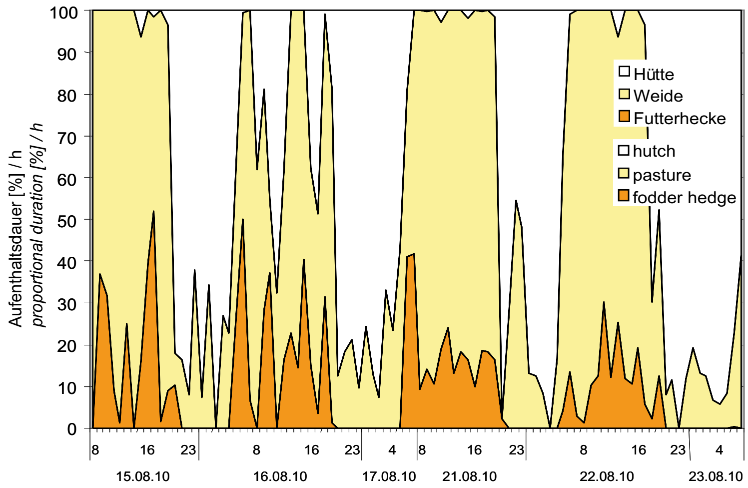
Provided that a good expertise in technology exists, Ubisense 7000 is a good alternative to direct observations and video recordings. The low weight of the “tags” allows interference-free positioning even for smaller animals. An event-induced automatic recording of the position will partly replace the human evaluation work which is done by observing and analysing videos. Even under extreme weather conditions, as occurred for example during the experiment, the system could be used. The sensors and the “tags” have to be protected against water, dust and animals. This is comparable to conditions in open dairy houses, especially if exercise yards should be monitored.

Fig. 4



Calibration area (08/19/2010) including box-whisker plots of deviation (euclidian geometry)

Abb. 5



Proportion of time goat kids spent in three fuctional areas (fodder hedge, pasture, hutch)

This raises the question of how accurate a positioning system should be, that is used in animal husbandry. Here 0.15 m seemed quite sufficient to locate animals in different functional areas either in-house or outdoors on pasture.

In practice, real-time positioning on farm-level is still a debatable point, even if there are first commercial applications with cattle in Denmark. Our study in the area of research on goat kids, as with any other species, indicates that a positioning system could facilitate behavioural observations in the future.

Literature

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