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# A DATA ACQUISITION SYSTEM FOR THE WIRE TENSIONING SYSTEM IN THE ROBOSHEPHERD

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**Abstract**. *Data acquisition hardware and software are often used by scientists and engineers in different types of research. Computer-based data acquisition systems are a very powerful and cost-effective solution for measurement and analysis. This paper presents the design of hardware and software of a computer-based data acquisition system for the wire tensioning system used in the autonomous system for herd keeping and breeding - Roboshepherd*

**Key words**: *Data acquisition, monitoring, wire tensioning, swarm robots, shepherd*

## 1. INTRODUCTION

The term "data acquisition" is usually applied to various kinds of measures, ranging from analog to digital signals of different types, from acquisition from a single sensor to complex acquisition [1]. Nowadays, the development of technology has enabled the installation of data acquisition and/or monitoring systems where there is a need for it. Researchers, engineers, doctors, and others have used these systems for various purposes. The authors in [2] presented the principles of a low-operational-cost Internet-based data-acquisition system with the embedded device for communication through General Packet Radio Service. In [3] a data acquisition system based on the ZigBee and Bluetooth network was proposed for factories and industries or environment monitoring, for measuring certain parameters such as temperature, humidity, and the level of gases present in the atmosphere. In [4] a data acquisition system based on the STM32 microcontroller was developed to monitor rotating machinery. The authors in [5] developed a remote input/output data acquisition system based on the embedded arm platform for measuring electrical and thermal parameters such as voltage, current, temperature and so on. The measured data can be displayed on the LCD screen of the system or sent to a remote monitoring system. The authors in [6] developed a data acquisition system for vehicle dynamics analysis based on the GPS technology. The developed system consists of a global positioning system (GPS) device, a portable mini-computer, and software. Measured data such as position, velocity and acceleration were saved and later imported in a special CAD application for post-

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processing. In [7] the authors used a data acquisition system based on the National Instruments 4472 Board and LabVIEW software during an experiment for the estimation of cable tension force.

Linjing and Peijiang [8] developed a real time monitoring system for animal husbandry logistics. The developed system uses the RFID technology to monitor the origin country of livestock and the environment during transport to assure the livestock's physique. Furthermore, Wang and Qi [9] studied the intelligent cloud animal husbandry platform.

The authors in [10] developed a cost-effective data acquisition system based on Lab-VIEW to continuously collect and display the electrical parameters of a stand-alone photovoltaic system, while in [11] a Zigbee-based wireless monitoring system was developed for online monitoring of a grid-connected photovoltaic system.

In [12] a data acquisition system for meteorological purposes based on a microcontroller was developed. This system collected meteorological information such as temperature, humidity, and radiation, while in [13] a similar system was used to monitor a greenhouse.

Benghanem [14] explained the design and implementation of a wireless data acquisition system for assessing solar energy, consisting of a set of sensors for measuring meteorological parameters. Gad and Gad [15] proposed a new sensor-based data acquisition system for solar energy applications, which is suitable for large and remote installations. The main advantage of the developed system is the way of recording data and the ease of changing the type of sensors. Koutroulis and Kalaitzakis [16] developed a computer-based data acquisition system for renewable energy source systems for measuring both meteorological and electrical parameters of systems, while Kalaitzakis et al. [14] presented the development of a data acquisition system for remote monitoring and control of renewable energy system (RES) plants based on the Client / Server architecture, which does not require the physical connection of the monitored systems to the data collection server, and which is in turn very important because RES plants are usually installed in inaccessible areas. The measured parameters are available on-line over the Internet. Karami et al. [18] described a portable continuous measurement toolbox that provides a robust and low-cost setup for indoor environmental quality monitoring and performance assessment. The toolbox consists of various sensors for indoor environmental quality performance measurement - temperature, relative humidity, illuminance, $CO_2$, $PM_{2.5}$, etc.

The authors in [19] reviewed systems for monitoring and data acquisition used in hospitals, especially in intensive care units, which are used to acquire, manage, and follow data related to the patient's health. In [20] the authors designed an in-shoe multisensory data acquisition system specially for patients with diabetes and peripheral neuropathy, who are susceptible to unnoticed trauma on the foot that can cause skin damage. The developed system can collect the data on temperature, pressure, and humidity in the patient's shoe which can be later used for analysis. In [21] the authors presented a 96-channel implantable neural data acquisition system that can perform spike detection and extraction within the body and wirelessly transmit data to an external unit.

This paper describes hardware and software of a data acquisition system for wire tensioning. The system is developed in order to collect and monitor several parameters that are necessary for proper operation of the wire tensioning system. The obtained acquisition system is applied to the autonomous system RoboShepherd.

The rest of the paper is organized as follows. Section 2 presents the developed data acquisition system. The data gathered during the experiment is given in Section 3, and the conclusions are presented in Section 4.

## 2. Data Acquisition System for the Wire Tensioning System

The RoboShepherd is a swarm robotic system that surrounds livestock animals in the field or compels them to follow a predetermined course by acting as a mobile, polygonal electric barrier. The system is made up of at least four robotic units, which are four movable pillars connected by wires to form an electric fence. A vertical pillar, a mobile platform on which the vertical pillar is supported, a wire tensioning system, and a force sensor make up each robotic unit. By using the motor, wire is wound on a winding reel of the wire tensioning system which is mounted on one robotic unit, and the second end of the wire is coupled to the other robotic unit via a force sensor (Fig. 1). The robotic units are serially connected and form a closed loop in this manner.

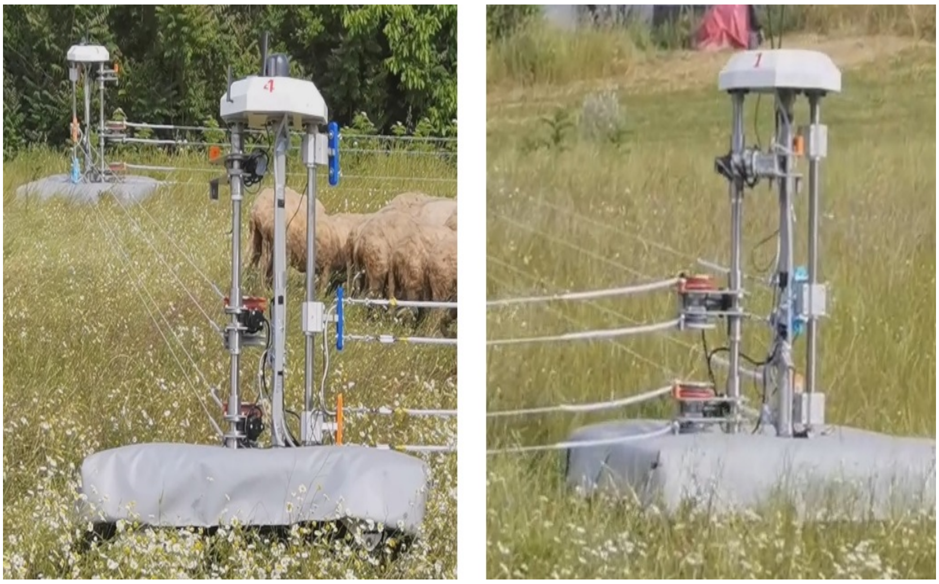


**Fig. 1** Force sensor and wire tensioning system mounted on robotic units

In order to collect and monitor several parameters required for the correct operation of the wire tensioning system, a data acquisition system was developed. The developed system collects data from different sensors, processes them and sends them to the control algorithms during the utilization of the RoboShepherd. Three robotic units were equipped with local, while the fourth robotic unit had a global data acquisition system. A block diagram of the local data acquisition system for the wire tensioning system is given in Fig. 2.

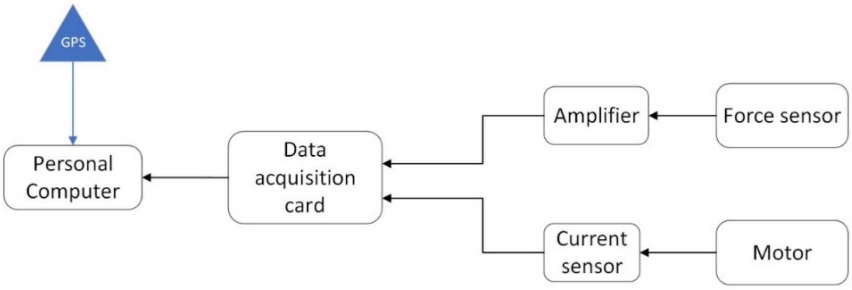
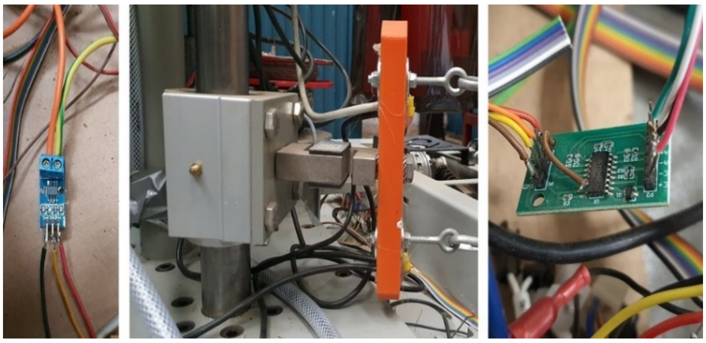



**Fig. 2** Block diagram of the local data acquisition system

The local data acquisition system consists of a personal computer (PC) with a wireless network card, global positioning system (GPS), data acquisition card, force sensor with amplifier and current sensor. The personal computer was industrial grade because of the harsh operating conditions (low/high temperature, possible shocks, etc.). Appropriate software was installed on the PC. A real time kinematics (RTK) GPS tracker with a long-range communication radio (LoRa) was used to determine the position of the robotic unit. The EMLID GPS Reach M2 module was used with a correction stream via LoRa to determine the position of the robotic unit within 1 cm accuracy. The GPS module was connected directly to the PC, while the GPS and LoRa antennas were installed on the top of the robotic unit (Fig. 3).


**Fig. 3** GPS module mounted on the robotic unit

Arduino Mega 2560 with 54 digital input/output pins and 16 analog inputs was used as a data acquisition card. Arduino was connected directly to the PC. To measure the tension force in wires, an industrial grade force sensor of up to 200 kg was used. This sensor was connected to the amplifier, and the amplifier was connected to the Arduino. To measure the current of the motor, a current sensor of 30 A was used. One side of the sensor was connected to the wire of the motor while the other side was connected to the Arduino. The current sensor, force sensor and amplifier are shown in Fig. 4.



a) b) c)

**Fig. 4** a) Current sensor, b) Force sensor and c) Amplifier for the force sensor

As the robotic units are serially connected, it means that the force sensor on one robotic unit measures the tension in wires which comes from the wire tensioning system that is mounted on another robotic unit. Therefore, during the process of wire tensioning, local measured force is wirelessly sent to the control algorithm of the wire tensioning system on another robotic unit.

The global data acquisition system is the same as the local data acquisition systems with the ability to gather all the GPS position data from other local data acquisition systems. The global data acquisition system was installed only on one robotic unit. The GPS data from other robotic units were transferred through the wireless network to the global data acquisition system. All gathered data was further used to calculate the distance between the robotic units or during the control of the wire tensioning system. The software for the data acquisition systems (Fig. 5) was developed in LabView.


**Fig. 5** Front panel in LabVIEW of the developed data acquisition system

## 3. FIELD TESTS

The developed data acquisition system was tested on a farm near the City of Niš, Serbia. The aim of the field test was to collect data which is important for the control of the wire tensioning system. For this purpose, two robotic units were placed on the location and connected with a pair of wires. The initial position distance between the robotic units was about 34 m. Then, a 30-second scenario was conducted. In this scenario one of the robotic units was moving straight, while the other was moving in a straight line and approaching the first one at the same time. The force in the pair of wires, the current of the motor which was used to tension the wires, and the position of both robotic units were measured using the afore mentioned sensors. The haversine algorithm [22], which determines the shortest straight-line distance between two specified locations, was used to estimate the distance between the robotic units, by using the latitude and longitude data from both GPS trackers. The obtained data are illustrated in Figs. 6-8.

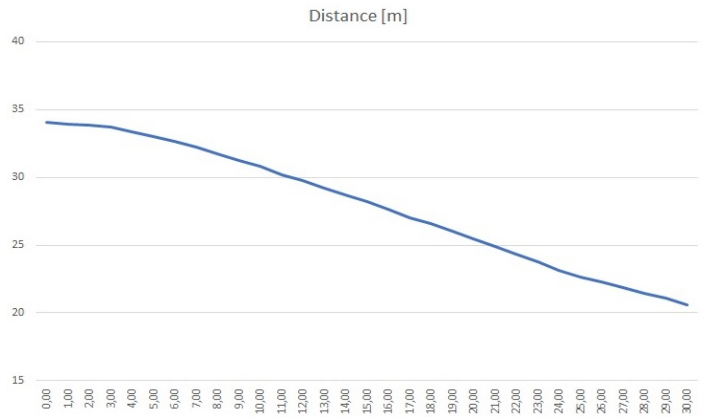



**Fig. 6** Calculated distance between the robotic units during the movement scenario

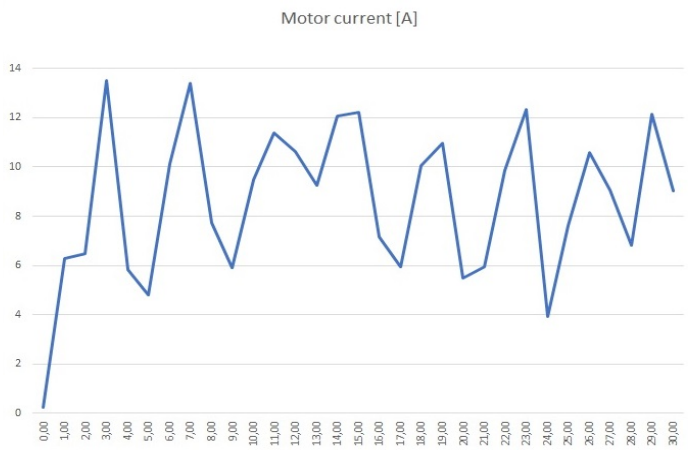



**Fig. 7** Measured motor current during the movement scenario

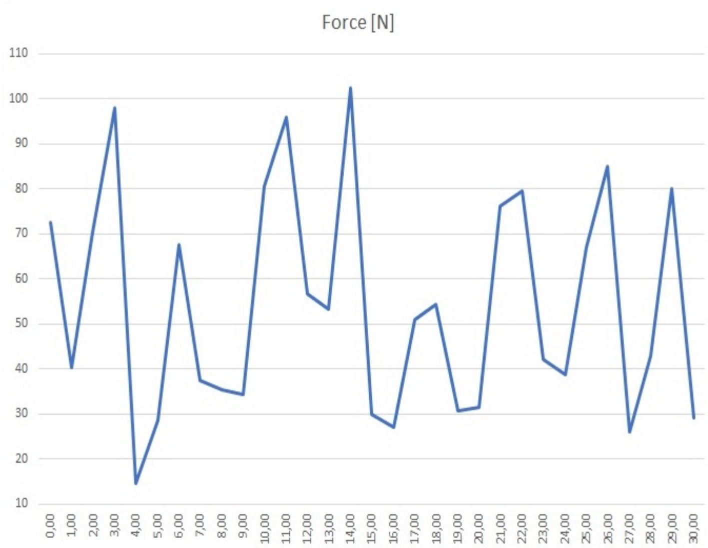



**Fig. 8** Measured force in wires during the movement scenario

As shown in Fig. 6, the distance between the robotic units determined using the haversine algorithm during movement dropped from the initial 34 m to 20 m due to one robotic unit approaching the other. Fig. 7 indicates that the lowest motor current was 0 A, which correlates with the moment before the start of the wire tensioning system, and then increased to the range between 4 A and 14 A during the tensioning of the wire. From the plot in Fig. 8 it can be deduced that the force in wires was around 70 N at the beginning of the scenario. This happened because of the manual pretension during the connection of the robotic units. The tension force dropped and rose during the movement of the robotic units.

## 4. Conclusion

Data acquisition systems are widely used to collect data for different purposes. The collected data can be used for various tasks such as monitoring or control of a system or can be stored for later usage. This paper presented a data acquisition system for the wire tensioning system in the Roboshepherd. The developed data acquisition system consists of different sensors that enable the measurement of tension force in the pair of wires, the motor current, and which can calculate the distance between the robotic units. The use of an inexpensive data acquisition board and current and force sensors reduced the cost of the developed system, yet still allowed good results to be obtained during use.

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