Development of a mobile autonomous chassis for studying grassland areas by using thermal cameras

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***Abstract* — This article focuses on the topic of using intelligent approaches and modern hardware and software solutions and systems in the study of pasture areas, by using infrared imaging and developing a mobile, autonomously driven chassis with the ability to robotize the processes of movement, capture the necessary data, processing the information and providing information about the investigated areas.**

Keywords— autonomous chassis, thermal cameras, image analysis, grasslands

I. INTRODUCTION

For the purposes of the intelligent management of pasture animal husbandry and the protection of biodiversity, it is necessary to implement innovative approaches, implemented through modern methods and systems for monitoring, managing and optimizing the use of pasture areas. When growing various biological units that need grazing, one of the most important things is related to both the technology and the process of feeding the animals, as well as the quantity, quality and condition of the natural food sources - the grass of the pastures used in their freely bred. The use of digital images and infrared thermographic analysis of the condition and quality of grass cover in pasture areas is a very suitable approach to achieve this goal. Carrying out this analysis remotely (remotely), through specially developed autonomous chassis, equipped with modern specialized technical methods and means of research and control of the grass mass is essential. The aim of this research is to develop and evaluate the feasibility of using an autonomous chassis equipped for remote investigation and monitoring of the quantity, condition and quality of grass cover of pasture areas in the breeding and feeding of cattle.

II. SYSTEM DESCRIPTION

For the purposes of research and intelligent management of processes for the assessment and control of grass cover in pasture areas, a specific terrain, defined in advance, which includes several small pasture areas, was selected. The used pastures are also examined in detail in [1,2], and the main

Fig.1. Location of the investigated pastures.

parameters are determined by aerial photography using an unmanned aerial vehicle (drone) and photogrammetry software. The terrain is located in the territory of the city of Kardzhali in the Republic of Bulgaria and has geographical coordinates 41°29'39.7"N and 25°28'44.8"E (Fig.1).

After the preliminary research and determination of all parameters necessary to determine the main characteristics of the developed chassis, such as the type of terrain, slopes, determination of the geographical coordinates of each specific point of the selected pastures, the volumetric characteristics of selected elements, the exact area of the pasture area and others, the distances between individual points in the horizontal and vertical planes are defined.

Fig. 2 presents the geographical coordinates determined with sufficiently high accuracy, through photogrammetric

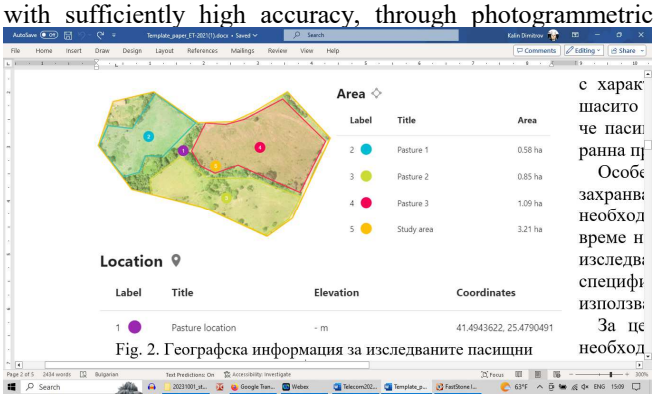

Fig. 2. Географска информация за изследваните пасищни

Fig.2. Geographical information about the researched pasture areas.

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recording and software processing of the three smaller pasture areas of the researched terrain, as well as many specific elements for the purpose of design and surveying with the developed specialized autonomous chassis.

During the design and implementation of the developed chassis, it is necessary to pay attention to both the necessary equipment for its construction and the equipment related to measuring equipment for research. At the same time, it is taken into account the possibility of its use both for the specific three pasture areas, as well as subsequently for the study of pasture areas which, in principle, have similar terrain and geographical characteristics.

When designing the chassis, the requirement to be able to move very slowly at a speed of less than 0.05m/s is taken into account, given the characteristics of the terrain, which also consists of rocky sections and unevenness, which in certain places can lead to overturning. This also places requirements for high cross-country ability, necessary high traction of tires with non-specific terrains and reliable suspension. The steering and other dynamic properties that affect its stability must allow movement in the described conditions.

Preliminary studies have shown the need for a minimum of four wheels, which is also the minimum number of thrusters to be driven. This will provide excellent traction given the traffic conditions, which combined with high clearance will ensure continuous movement at the required speed on the studied terrain.

The electric motor must have high torque and dynamic control, which is transmitted from a transmission with the parameters required for the terrain, which must be at least two gears. They must provide, if necessary, low speed and high torque, and accordingly more high speed combined with less torque for the different conditions and specifics of the research objectives. It is necessary for the transmission to also provide reverse movement, which will provide high cross-country ability under different terrain conditions. It is necessary to achieve certain noise levels when moving the autonomous chassis to prevent environmental pollution with this component.

Due to the specifics and conditions in which the chassis will be operated, it must have a high degree of moisture protection and be able to be used even in high humidity and heavy rains. The components should have characteristics that allow the use of the chassis in a wide temperature range, given that grazing animals use these terrains from the earliest spring to late autumn.

Special requirements are placed on the power element (battery) of the chassis. It needs to be of high capacity and offer a time of operation to achieve the objectives of the research under the specific conditions depending on the specifics of each terrain on which it will be used.

For research purposes, the autonomous chassis needs to be equipped with a navigation controllable and controllable system and control software to enable both traffic routing and exploration of designated grazing areas. For the purpose of safety and ensuring maximum efficiency in the transmission of information, the specialized chassis must be equipped with equipment enabling the performance of the specified objectives, namely the transmission in real time of telemetry data on its movement and information from all receivers that have purpose and collection of the necessary data for the study. In addition, when carrying out a planned survey of a specific pasture, the collected information must be able to be stored on an electronic medium and downloaded in a suitable format when taken to the center for intelligent management of the pasture massifs.

The additional equipment includes systems determining the autonomous movement in case of loss of any communication between the chassis and the operator, as well as a system directly related to the movement of the chassis in the specified area, such as determining the area of the pasture itself. It is necessary to move independently again without connection to a communication center through artificial intelligence, controlling and managing everything related to movement, completing the assigned tasks and returning to the communication center independently on the chassis.

To ensure autonomy, it is necessary to have sensors, both for linear accelerations (accelerometers), and from a system of receivers for angular accelerations (gyroscopes), which are connected to the control information system. The system will be designed and programmed specifically for the defined activities related to the intelligent management of resources and pastures, and it is necessary to develop complex algorithms and a specification to make an independent decision and take control of the movement of the chassis itself until it arrives at the control room. center or restore communication with the control center. Autonomy requires that even with the loss of any connection with the communication center and operator, the chassis autonomously, independently decides (according to set algorithms) how to continue its movement on the specified (pre-set) grazing area of and complete the specified tasks embedded in the research process the state and quality of the grass massifs in pasture areas, with the final result of arriving at a (predetermined) end point for transmitting the collected information. The chassis must also have an autonomous intelligent obstacle detection and avoidance system working in conjunction with a 3600 wide-angle camera or similar equivalent of several cameras covering the area around the chassis. A block diagram of the specialized chassis for the study of grassland areas is shown in Fig.3.

The control system receives information about the state of the chassis (System state), which includes linear and

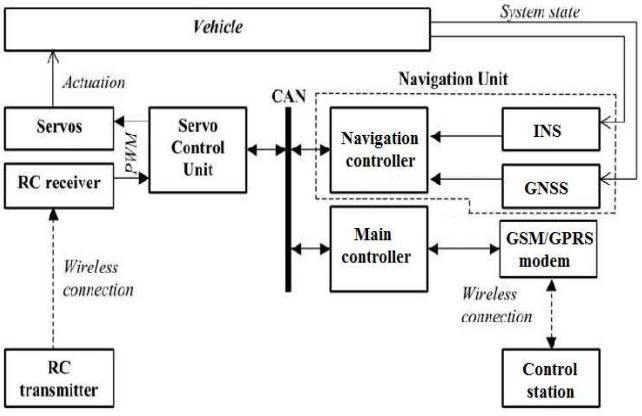

Fig.3. Block diagram of the designed chassis.

angular accelerations along the three axes and data from the rotary encoders of each wheel, each of which has two outputs A and B to determine the speed and direction of rotation. This data enters the input of the navigation controller (navigation controller), which determines the location of the chassis and the vector of movement (speed and direction of movement). This information is transmitted via the CAN bus to the main microcontroller, which on the one hand transmits the information to the control center (Control center) via a GPRS connection, and on the other hand sends commands for remote control to the executive mechanisms (Servos). Their management is also possible through a locally operating remote control (RC transmitter / receiver).

For the purposes of research and determination of the condition and quality of the available food raw materials - the grass, grass and leaf mass of the pastures, the autonomous chassis must be equipped (equipped) with a specialized system for determining the type, condition and quality of the researched grass for grazing. The developed system is equipped with hardware and software specifically for the purposes of intelligent management in animal husbandry and more specifically for the management of pastures. The block diagram of the specialized measuring system that will be located on the specially developed chassis is shown in Fig.4.

The minimum necessary equipment to be mounted on the developed chassis for the purpose of surveying the grass masses of the pasture areas is:

• normal and thermal imaging camera for examining the condition and quality of the grass and leaf litter of the examined pasture;
• barometer (P) for measuring the atmospheric pressure during the research and filming of the pasture itself;
• sensor for ambient temperature (T);
• sensor for measuring the humidity of the environment (RH);
• receiver for measuring the direction (WIND_DIR) and speed (WIND_ROT) of the wind;
• Inertial sensor for measuring the slope of the terrain (INS);
• Dual-frequency L1/L5 GNSS receiver with increased accuracy (the sub-meter range) for creating a terrain map and for synchronizing geolocation with camera data;
• Analog - digital inputs and outputs for drive control (GPIO);
• GSM/GPRS modem for real-time data transmission to a remote server and/or Bluetooth transceiver for short distance communication.

After researching and analyzing the type, condition and quality of the grass mass of all three pastures studied, according to the developed algorithm, information will be given on which of the pastures the grass is most suitable for eating and will suggest to the shepherd to take the herd of herbivores there.

In order to achieve comprehensive results regarding the set objectives, it is necessary to envisage the possibility of robotically moving the cameras (normal and thermovision) around the chassis to cover as large an area of the captured images as possible. The same can be achieved by installing several such cameras to fulfill the intended purpose.

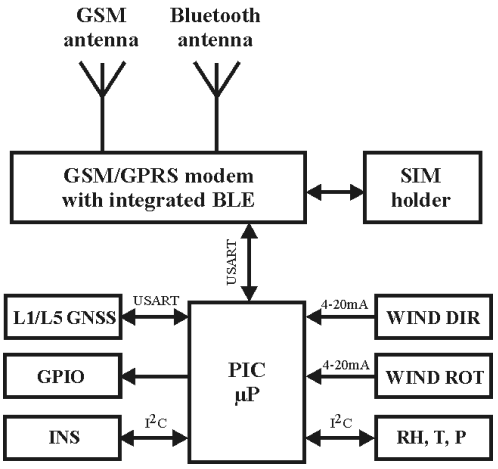

Fig.4. Block diagram of the developed system for the study of grassland massifs

The system must, after researching and analyzing the amount, type, condition and quality of the grass mass, according to the developed algorithm, provide information on which of the pastures the grass is most suitable for consumption and will suggest to the shepherd to take the herd of herbivores there.

The data transmission is accomplished by quad-band GSM/GPRS modem with integrated Bluetooth Low Energy (BLE) module. The measured data are encapsulated and coded into 25 bytes packets which are sent via GPRS connection to the remote server via HTTP connection. The packets are received and decoded by packet sniffer and stored in the MySQL database. The data may be accessed by the users from a web browser by the installed Apache server (Fig.5).

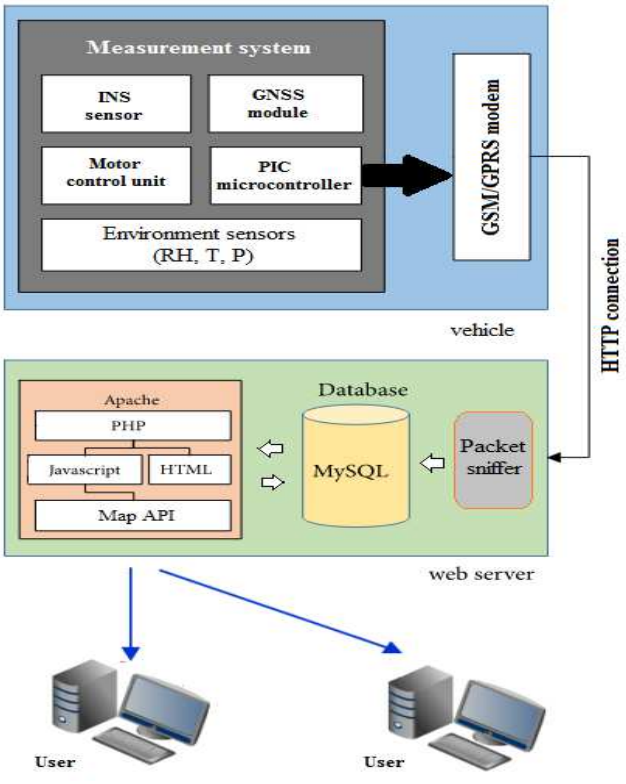

Fig.5. Block diagram of the developed system for the study of grassland massifs

III. Results and discussion

Since the development of a specialized chassis and system contains many and heterogeneous sensors, software and hardware developments and is under development, the article presents only the developed chassis with some of the necessary receivers and cameras when testing the navigation system and the autonomous movement of the pasture fig. 6.

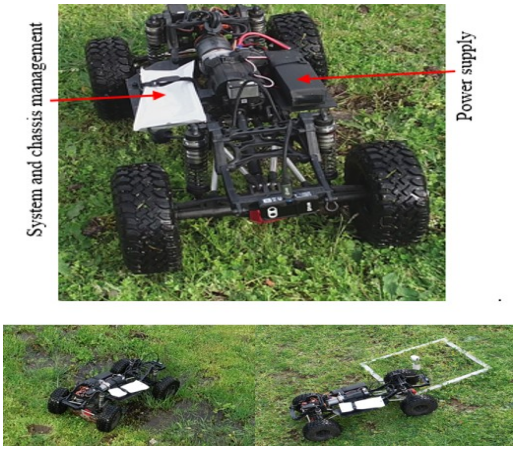

Fig.6. The developed chassis with installed cameras and information transmission system.

To verify the correct operation of the chassis, initial research was carried out on the pasture, with the management and control system of the movement of the chassis tracked by drone from the air (Fig. 7).

Fig.7. Tracking the movement of the landing gear with an unmanned aerial vehicle

After entering the necessary geographic coordinates of the three pasture areas, the system determines the optimal route and determines the number of thermographic images of the grass mass. After completing the walk in the designated areas, the chassis is returned to a designated location and the images are downloaded for post-processing and analysis.

Fig. 8 shows images from the thermal camera taken during the research conducted on the selected for the purposes of intelligent animal husbandry and management of pasture massifs.

IV. Conclusion

The present study presents the possibilities for implementing field methods and technical means for

Fig.8. Thermal camera image of the investigated pasture areas

intelligent management and making correct decisions in the management of several pasture areas.

Compared to conventional practice, the use of the developed autonomous chassis with the possibility of robotization and process automation provides a time-saving opportunity for efficient and large-scale surveys of leaf and grass mass in several small pastures. Using a portable management system as a reference system, the method of thermographic imaging of the grass mass of pastures can be used in managing the proper feeding of herbivores. With the development and implementation of such intelligent systems, feeding ruminants with suitable and quality grass mass and proper management of pasture areas according to the available biomass will increase the efficiency of animal husbandry and improve the quality of milk and meat produced for food.

The decisions that are made in the management of pastures in relation to the grass biomass needed to raise animals for milk or meat must meet the modern expectations and demands of society, as well as the ever-increasing demand for quality food products.

The research shows that the use and implementation of intelligent solutions for the organization and management of food biomass in pasture areas has great potential and is the only correct approach in modern technological times and the high demands on food products and the proper management of natural resources and stocks.

Acknowledgment

The research leading to these results has received funding from the Ministry of education and science under the National science program INTELLIGENT ANIMAL HUSBANDRY, grant agreement № Д01-62/18.03.2021/

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