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HEALTH MONITORING OF EQUINES OF THE MILITARY POLICE OF PARANÁ THROUGH THE USE OF ARTIFICIAL INTELLIGENCE

MONITORAMENTO DA SAÚDE DOS EQUÍDEOS DA POLÍCIA MILITAR DO PARANÁ ATRAVÉS DO USO DE INTELIGÊNCIA ARTIFICIAL

SUPERVISIÓN DE LA SALUD DE LOS EQUINOS DE LA POLICÍA MILITAR DE PARANÁ MEDIANTE EL USO DE LA INTELIGENCIA ARTIFICIAL

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ABSTRACT

This article focused on evaluating a technological proposal aimed at developing a remote equine health monitoring system, mediated by Artificial Intelligence (AI). The results of the research led to the conclusion that this technology is fully feasible and will make it possible to monitor the health status of the corporation's animals distributed in the operational units in the capital and in the interior. The system is directly related to measuring the animal's body temperature, monitoring the feeding routine and lameness, where this information, captured by specific hardware distributed in paddocks and stalls, will allow the data to be provided to the AI, which will cross-reference it with the individual information of the monitored equine and, after carrying out the analysis and, if any alterations are identified, will immediately send an alert to those responsible, via SMS, messaging platforms or e-mail, informing them of the alterations found. Regardless of whether or not it finds any alterations in any equine, after the end of the 24-hour cycle, it will issue a report on the entire herd with the information received, thus enabling patterns to be identified and animal health to be monitored. As the system will monitor the animals on a daily basis, it will be possible to provide prompt veterinary intervention and thus improve the corporation's equine animal welfare practices in the health sphere, thereby making it possible to save financial and human resources.

Keywords: Police Sciences. Artificial Intelligence. Mounted Policing. Public Security.

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RESUMO
Este artigo teve como foco a avaliação de uma proposta tecnológica voltada para o desenvolvimento de um sistema de monitoramento remoto da saúde equina, mediado por Inteligência Artificial (IA). Os resultados da pesquisa levaram à conclusão de que essa tecnologia é totalmente viável e possibilitará o monitoramento do estado de saúde dos animais da corporação distribuídos nas unidades operacionais na capital e no interior. O sistema está diretamente relacionado à medição da temperatura corporal do animal, ao monitoramento da rotina alimentar e à claudicação, onde essas informações, capturadas por hardware específico distribuído em piquetes e baias, permitirão que os dados sejam fornecidos à IA, que os cruzará com as informações individuais do equino monitorado e, após realizar a análise e, caso sejam identificadas alterações, enviará imediatamente um alerta aos responsáveis, via SMS, plataformas de mensagens ou e-mail, informando-os das alterações encontradas. Independentemente de encontrar ou não alterações em algum equino, após o término do ciclo de 24 horas, ele emitirá um relatório sobre todo o rebanho com as informações recebidas, permitindo assim identificar padrões e monitorar a saúde dos animais. Como o sistema monitorará os animais diariamente, será possível fornecer intervenção veterinária imediata e, assim, melhorar as práticas de bem-estar animal equino da corporação na esfera da saúde, possibilitando a economia de recursos financeiros e humanos.

Palavras-chave: Ciências Policiais. Inteligência Artificial. Polícia Montada. Segurança Pública.

RESUMEN
Este artículo se centró en evaluar una propuesta tecnológica destinada a desarrollar un sistema de monitorización remota de la salud equina, mediado por Inteligencia Artificial (IA). Los resultados de la investigación llevaron a la conclusión de que esta tecnología es totalmente viable y permitirá monitorizar el estado de salud de los animales de la corporación distribuidos en las unidades operativas de la capital y del interior. El sistema está directamente relacionado con la medición de la temperatura corporal del animal, el control de la rutina de alimentación y la cojera, donde esta información, capturada por hardware específico distribuido en prados y establos, permitirá que los datos se proporcionen a la IA, que los cotejará con la información individual del equino monitoreado y, después de realizar el análisis y, si se identifican alteraciones, enviará inmediatamente una alerta a los responsables, a través de SMS, plataformas de mensajería o correo electrónico, informándoles de las alteraciones encontradas. Independientemente de si encuentra o no alteraciones en algún equino, al finalizar el ciclo de 24 horas, emitirá un informe sobre toda la manada con la información recibida, lo que permitirá identificar patrones y controlar la salud de los animales. Dado que el sistema supervisará a los animales a diario, será posible proporcionar una intervención veterinaria rápida y, por lo tanto, mejorar las prácticas de bienestar animal de la corporación en el ámbito de la salud, lo que permitirá ahorrar recursos financieros y humanos.

Palabras clave: Ciencias Policiales. Inteligencia Artificial. Policía Montada. Seguridad Pública.

1 INTRODUCTION

Humans and horses have had a long relationship since the beginning of animal domestication, with horses playing an important role in many of mankind's great historical achievements. This coexistence predates the earliest records of civilisation, when they were used in agriculture, transport and warfare. Today, they are used in other activities such as leisure, sports, public safety and even therapy for patients with disabilities and/or limitations, as well as in the pharmaceutical industry. Even though they are recognised for their functional capacity and athletic form, one of their main functions is still daily work in agricultural activities. According to 2014 data, Brazil has the fourth largest horse population on the planet (58.832 million head), with 5.451 million head, preceded only by the USA (10.260 million head), Mexico (6.355 million head) and China with 6.027 million head.

The Brazilian equestrian industry is highly significant economically in the tourism, transport, saddlery equipment, pharmaceutical and veterinary medicine sectors, and socially in the areas of public safety, education and social inclusion through Equine-Assisted Therapy centres. In order to avoid economic losses for the above-mentioned sectors, health control and equine management must be adopted by all breeding sites to prevent diseases from causing the death of animals and considerable financial losses to owners. However, it is not possible to avoid financial difficulties and permanent damage to the health of animals when the disease is not identified early due to the lack of regular clinical examinations or the lack of attention to subtle changes in animals by those who monitor them.

Technological advances and the implementation of new sciences in agriculture, combined with equine health monitoring, are allowing this scenario to change. AI, in particular the Machine Learning system, allows for the optimisation of care, monitoring of vital signs, behaviour and performance, as well as the identification of behavioural and physical changes that may indicate an emerging disease or stereotype.

Another factor that is no less important and directly related to horse management is welfare, an issue that is increasingly on the agenda in Brazil and worldwide. In the context of animals used in public safety, this is a matter of significant importance, because when abnormal behaviour, the presence of disease, injuries, movement difficulties and reduced ability to exercise are detected, they immediately become the subject of extreme attention in police units.

Therefore, the objective of this study is to review the available literature on the importance of new technologies for remote monitoring of horse health and their application in the Military Police of Paraná (PMPR), with the aim of anticipating the care of the corporation's animals and, thus, optimising the use of human and material resources in a

rational manner, from the deontological perspective of animal welfare concepts, considering that the development of debates on this topic is increasingly in vogue in Brazil and worldwide, leading various sectors of society to discuss better conditions for animal husbandry, in light of two of the five freedoms of animal welfare, specifically freedom from discomfort and freedom from pain and disease.

2 LITERATURE REVIEW

2.1 THE HORSE INDUSTRY IN THE 21ST CENTURY

The global director of Alltech's Equine and Minerals Divisions, Steve Elliot, says that the equine industry has a significant global impact of around US$ 260 billion. Similarly, Christina Jones, founder of the Equine Business Association (EBA, 2022), points out that the equine industry is like a hidden champion, in which most people outside equestrian circles, and many who are part of it, are unaware of the magnitude and importance of the sector to the global economy.

In the United States, the horse industry has a greater economic impact than the film industry, generating around seven million direct and indirect jobs, two million of which are horse owners.

The same economic value is seen in the European Union. There is, however, a growing consensus that the equine industry has changed from an agricultural and industrial activity to a business firmly rooted in various sectors, for example sport and leisure. Furthermore, advances in the horse industry are economically beneficial and help generate new types of activities.

There is also an increase in new developments in the use of horses in leisure, tourism, ethology, therapy and social rehabilitation. Likewise, producers have new objectives, such as reducing stress and creating emotional connections with horses by riding in comfort. Therefore, the horse industry is now at the crossroads of the agricultural, tourism, sports, leisure, public safety and kinesiotherapeutic sectors.

2.2 EQUINE INDUSTRY IN BRAZIL

The equine industry is one of the fastest growing in Brazilian agribusiness and generates around R$30 billion a year, surpassing the 2016 data from the Brazilian Institute of Geography and Statistics IBGE (2022), which indicated the generation of R$16 billion in the Brazilian equine industry, with a growth of 87.5% in four years.

According to a publication by the National Society of Agriculture, 70% of those who participate in this market as a customer perceive equestrianism as leisure and have been

involved in the equestrian environment for less than six years. This gradual contextual change in the sector also has an impact on the way professionals work.

Today, Brazil ranks fourth as the world's largest equine herd, with 5.9 million head IBGE (2022). In addition to the traditional Crioulo horse, other national breeds stand out, such as the Mangalarga Marchador, which generates approximately 240,000 direct and indirect jobs, and the Brazilian Equestrian, a breed with a lot of added value in its breeding.

Foreign breeds also contribute to the growth of horse breeding Brazilian, such as the English Thoroughbred (PSI), which generates more than R$ 240 million in its reproduction, as well as tourist activities and the Quarter Horse (QM) with more than half a million registered animals, (Boesing, 2020).

2.3 THE USE OF HORSES IN PUBLIC SECURITY

The visibility of the police is strongly linked to the feeling of security, and in this context mounted policing proves to be a strong option, where a hypermobile policing team has great visibility, directly meeting the need for a feeling of security desired by the population (Giacomantonio et al. 2013), and is directly linked to the fact that a mounted garrison is at a higher level in relation to the population, a disposition known as command (Bondaruk 2005). Regardless of whether it is close to a crowd or far away, a mounted garrison is always visible from great distances compared to others.

Studies carried out in England show that mounted policing is six times more effective than policing on foot when it comes to interacting with the public.

This imbalance is directly related to the fact that hip-mobile policing is more attractive than policing on foot, because the policeman on horseback encourages repeated encounters with the population in the same area due to the attraction of the horse. Another factor to note is that mounted patrols are positively accepted by people from all walks of life, ages and ethnicities.

Mounted policing generates positive evaluations of public safety on the part of the population, as a result of increased visibility and generating substantially higher levels of engagement with community members than equivalents such as officers patrolling on foot. In addition to this characteristic, hip-mobile policing also offers the capacity to provide a response to crowd control situations and can intervene cohesively and in ways that generate more efficient results than other options, such as on-board or on-foot personnel. Secondarily, teams on horseback are able to progress over rough terrain, in addition to their applicability in search and rescue operations.

Like so many other aspects of police work, Mounted Policing offers the public a reassuring promise, especially at public events, and potentially a warning to delinquents, as it incorporates physical force (Giacomantonio, et al. 2013).

2.4 APPLICATION OF MOUNTED POLICING IN THE CONTEXT OF COMMUNITY POLICING

Mounted police generate positive evaluations of policing in neighborhoods, increasing visibility and generating substantially higher levels of proximity to the population when compared to their foot patrol counterparts (Giacomantonio, et al. 2013).

Hypomobile patrolling is a sure bet for community policing, as it enables patrol officers to identify the causes of the population's problems, with a view to eliminating them. This process of patrolling promotes links with associations or members of the local community, with the aim of establishing and developing a bond of collaboration and mutual trust. It also increases the exchange of information between the community and the Security Forces, providing future actions against criminals (Fraga, 2006).

In order to achieve a positive image among the public, actions must be taken to strengthen the link between the two. Social visibility actions can take the form of distributing pamphlets with legislative clarifications or merely informative leaflets, taking part in events, conferences or lectures related to security, meetings with committees or risk groups, visits to the Units, or equestrian demonstrations.

These actions lead to an increase in the relationship of trust with the population, allowing the security agencies to discuss urban planning issues with the community, which contribute positively to improvements in security conditions and quality of life (Fraga, 2006).

The population considers mounted policing to be another way of policing, thus developing a feeling of closeness and security, as it is an imminently preventive means of policing.

2.5 APPLICATION OF HORSES IN THE CONTEXT OF PUBLIC SECURITY IN PARANÁ

Mounted policing is still an active part of the PMPR's operational grid, despite the reduction in human resources made available. The main form of application of this process is ordinary, ostentatious policing at agricultural shows, concerts and sporting events, as well as honor and funeral escorts. In the context of community policing, the PMPR provides free equine therapy services at the three OPMs, as well as riding lessons for students at the PMPR schools.

It also provides supervised internships for courses in Physiotherapy, Zootechnics and Veterinary Medicine, thus allowing for greater integration with the academic community, which generally culminates in the production of scientific articles.

3 MAIN PARAMETERS PHYSIOLOGICAL OF EQUINEPASSIBLE REMOTELY MONITORED

In the international economic context, the equine industry is directly linked to the successful maintenance of horses' state of health, a task that is directly focused on animal health professionals. Changes in the animal's general health are collected through clinical examination with the help of health parameters such as Respiratory Rate (RR), Heart Rate (HR) and Rectal Temperature (RT), which are chosen because they immediately indicate any changes in health. The aim of the clinical examination in horses, as in other animal species, is to identify and locate problems in an organ or system quickly. When done correctly, the information obtained from the examination can focus attention on a region or system and ensure that less apparent or unexpected problems are not overlooked, Speirs (1999)

HR and RR are widely used to observe the physiological performance of horses (Oliveira et al. (2014). Rectal temperature is also used, but can be influenced by solar radiation, relative humidity and atmospheric movements, Lee et al. (1976).

Table 1

Values of normal physiological parameters in horses.

Age group	HR (bpm)	FR (rpm)	TR ($^{(o)}C$)
Adult	30-40	18-20	38.2 (± 1)
Foal	40-80 (1) 130-150 (2) 70-100 (3)	60-80 (4) 20-40(5)	37,2-38,9

Source: Speers (1999) and Cunningham (2004)

HR can be used to assess the physical conditioning of animals for imposed exercise and can help determine the horse's ability to withstand exertion, according to Senna et al. (2017).

It is also an important parameter for monitoring athletic performance, being widely studied in equine sports medicine Evans (2000) and is easily applied even in field studies, Oliveira et al., (2014). Aspects such as stress, excitement, fear, pain or improper handling can increase HR, Boffi (2007). Accordingly, HR can be measured through movements of the chest, abdomen and nostrils or by listening to the movement of air through the airways (Speirs, 1999).

The balance between body heat gain and loss results in total body temperature, which follows the circadian cycle, repeating itself every 24 hours, with a maximum between 17 and 19 hours and a minimum between 4 and 6 hours Robertshaw (2006).

Heat stress depends on internal heat production and factors that influence heat exchange, which in turn depends on the temperature and vapor pressure gradients between the animal and the environment (Silanikove, 2000).

Thermal balance is maintained at relatively constant levels, as there is a balance between heat gain and loss. Factors that increase body heat production include exercise, shivering, imperceptible muscle tension, increased chemical metabolism, drug reactions and increased external heat, Hines (2004). For Hickman Junior et al. (2004), physical temperature makes it possible to assess whether, under conditions of heat stress, animals are able to maintain their temperature within normal limits, which in horses can vary between 37.2ºC and 38.2ºC, Cunninghan (2004).

In horses that are active during the day, in general terms, minimum temperatures are observed in the early morning and maximum temperatures in the early afternoon (Swenson, 1988).

Elevation of body temperature above normal is one of the most common clinical problems encountered and, although classically associated with infection, in addition to a variety of disorders that can cause an increase in body temperature, such as heatstroke, anhidrosis, malignant hyperthermia, disorders of the central nervous system and reactions to certain toxins or drugs, Hines (2004).

4 AI CONCEPTS

AI is an area of computer science that studies how it is possible for machines to copy human intelligence, and in recent years the concepts point to any computerized system or automated function, however, the difference between an AI system and traditional software is the ability to make informed judgments and decisions in response to data patterns provided (Sharmah et al, 2019).

AI is often defined as the development of computer systems capable of performing intellectual processes done mainly by human beings, such as reasoning, understanding meaning, recognizing patterns, simulating logical reasoning and learning (Copeland, 2020). In addition, AI is a system that gives machines and electronic devices the ability to think and act like human beings, adapting, learning and performing tasks, allowing them to process and analyze large amounts of data.

AI is made up of sensors that collect data from the environment in its raw state, actuators that work to change the characteristics of the environment and, finally, the main part of an AI system, its operational logic, where for a given objective or objectives, based on the data collected by the sensors, the operational logic provides output for action by the actuators, in the form of predictions, recommendations or decisions that may influence the state of the environment.

Initially, AI was divided into two categories: symbolic and connectionist. Symbolic AI refers to the way in which human beings reason. In this category, the system is provided with manual input and problem-specific data so that it can reason and make decisions, such as expert systems. While connectionist AI aims to imitate how the human nervous system processes information, in this category it is possible to deduce patterns automatically from existing data, which leaves symbolic AI somewhat obsolete (Granatyr, 2017).

Some technologies are essential for its development, such as Machine Learning, Deep Learning and Reinforcement Learning, and others that are interconnected, such as supervised learning, Neural Networks, Cognitive Computing, Fuzzy Logic and Long-Short Term Memory (LTSM) and natural language processing (PLN) (Britto et al. 2022).

Machine Learning is at the intersection of statistics, AI and computer science and works as a mechanism for extracting knowledge from data. It is an application of AI and complements other technologies such as robotics, image recognition and natural language processing (NLP) systems Kaplan (2018). According to Samuel (2020), Machine Learning is the field of study that allows computers to learn to perform specific actions without having been explicitly programmed to do so.

The three most common learning methods for Machine Learning systems are supervised learning, unsupervised learning and reinforcement learning, Britto et al. (2022).

Supervised learning is a method whereby a system is fed a series of pieces of information and their respective results. From this, the system creates patterns so that, based on the new information it receives (input), it can find the results (output) by itself, without a technician showing the expected result (LAPIN (2021).

In unsupervised learning, the only information known to the system (input) is what is provided, and no answer (output) is given by the algorithm, which means that the system needs to infer on its own the structure that encompasses the data provided and then provide outputs without human intervention, Kaplan (2018). The system must distinguish patterns from the incoming data and group it into specific categories. Web search services use this machine learning system to operate, Andrew (2020).

In reinforcement learning, on the other hand, the AI system receives input data, but is given little or no sample results during its creation. This leaves the algorithm free to make its own decisions. The difference is that, with each decision, a signal is given as to whether the decision is useful or not. The goal of the system, over time, is to maximize the rewards received. This method is used, for example, on e-commerce sites or streaming platforms, Srinivasam, (2020).

Deep Learning is an AI function that mimics the activity of the human brain to create patterns for information processing and decision-making. Deep Learning is a subset of machine learning in the field of AI that can control learning from unstructured information or networked data. Also known as deep neural learning, Deep Learning is a subset of Machine Learning. This allows it to process and predict data using neural networks (Chatterjee,2020), requiring "training". Among the activities to be developed is "training" a computer to perform human-like tasks, such as speech recognition and image identification, improving the ability to classify, recognize, detect and describe using data, using large neural networks with many layers of processing units, taking advantage of advances in computing power and improved training techniques to learn complex patterns in large amounts of data. The Long-Short Term Memory Neural Network (LSTM) is a type of recurrent neural network used to train the ANN architecture (Okut, 2021).

Artificial neural networks (ANNs) are computer systems that mimic and simulate the function of the human brain to analyze and process complex data in an adaptive approach. They can implement massively parallel calculations for mapping, function approximation, classification and pattern recognition processing, which require less statistical training. In addition, ANNs have the ability to identify highly complex non-linear connections between outcome (dependent) and predictor (independent) variables using multiple training algorithms Okut (2021).

Another important AI tool is Cognitive Computing, which aims to create systems that interact in a natural way with human beings, where it can propose reliable operational alternatives based on research, thought and complex analysis (Britto et al. 2022).

Fuzzi Logic is an extension of Boolean logic based on the mathematical theory of fuzzy sets, and is a generalization of classical set theory, where by introducing the concept of degree in the verification of a condition, thus allowing it to be in a position other than true or false, Fuzzi Logic brings a valuable logical proposal that allows flexibility of reasoning, which considers inaccuracies and Uncertainties (Dernoncourt, 2014).

4.1 MAIN PATHOLOGIES CORRELATED WITH CHANGES IN EQUINE PHYSIOLOGICAL PARAMETERS

Among the main toxins that affect horses, those produced by Clostridium tetani (Zappa; Francisco, 2021) stand out as the cause of temperature rises of up to 4$^{(o)}$C, a disease related to management such as castrations, vaccinations, post-operative and umbilical infections, Pedroso et al. (2012).

One of the main causes of considerable losses in herds is Equine Infectious Anemia (EIA), a retroviral disease caused by the EIA virus (EIAV), which is a chronic and debilitating macrophage-tropic lentivirus of all equines, including horses, mules and donkeys, where the main clinical signs are elevated rectal temperature, apathy and inappetence. The zoonosis known as Glanders is also another infectious and contagious pathology that affects horses and is directly linked to major losses in equine farming. It is a pyogranulomatous disease (purulent inflammation), characterized by respiratory, lymphatic and skin lesions in horses, caused by the bacterium *Burkholderia mallei*, where one of the clinical signs is elevated temperature (Said, et al. 2016).

Equine *Influenza*, caused by the *Influenzavirus* A equi virus, also known as equine influenza, is highly contagious and attacks the respiratory system regardless of breed, sex or age, causing acute infection, and is considered to be the most important respiratory disease of the species, one of its characteristics being a high temperature (Villalobos, et al. 2011).

Changes in body temperature in mares in oestrus are observed in significant values in the hours immediately prior to ovulation (M.C. Bowman, 2007), and are also a method for monitoring the evolution of ovulation, where significant variations in temperature values are observed between oestrus cycles.

Diametrically opposed to hyperthermia is hypothermia, a state characterized by a reduction in body temperature below normal, which occurs as a result of the exhaustion of metabolic factors that protect against low temperatures, which are correlated with the depletion of hepatic and cardiac glycogen, as well as concomitant slowing of the heart and hemoconcentration, due to the detour of blood to the tissues (Swenson, 1988).

In accidental cases, hypothermia is when the body's ability to produce heat is overloaded, often in association with adverse environmental conditions. It is a spontaneous decrease in core body temperature independent of any actual disruption in the thermoregulatory system.

Pathological causes of hypothermia should be considered when there is no clear reason for accidental hypothermia. In pathological hypothermia, there is an association with disorders that decrease metabolic activity or act directly on the thermo-regulatory center,

such as intracranial disease, endocrine disorders or sepsis. When hypothermia occurs in the context of systemic inflammation, it is often considered to be a thermal regulatory response.

Another class of pathologies common in horses are those related to the locomotor system, defined as lameness, which is a structural or functional disorder in one or more limbs that is manifested during movement at a walk, trot or canter, or even in station, and can be caused by infections, trauma, congenital or acquired anomalies. Lameness can be defined as limb support, limb suspension, mixed or complementary (Stashak, 1994).

4.2 USING AI TO MONITOR EQUINE HEALTH

4.2.1 Microchip monitoring

Electronic animal identification is the first step towards an information system that can be useful for monitoring the health status of horses (Iudith et al. 2014). As a result of the high development of microelectronics, there is a wide range of microchips and readers on the market that can be used in herds combined with different methods, Nazareno et al. (2014). The technology used in these devices is Radio Frequency Identification (RFID), which uses radio frequency or magnetic field variations to communicate between electronic components and identify them, Barge et al. (2012).

RFID systems are made up of microchips, readers, software that processes information and a transponder, which is the system's data flow device, usually consisting of a coupling element and a microchip (Finkenzeller 1999).

Readers can be autonomous units without human intervention, integrated with a computer or a CL (serial command) that captures information about the reading of microchips and subsequent analysis of the information.

In horses, the most common type is the passive transponder, which does not have its own power source for activation and requires a reader (Reiners et al. 2009). It should be small, light and robust, with an operational lifespan longer than the lifespan of the horse, with a protective cover for the electronic identifier, usually made of bioactive glass for injectable transponders. The differential of this system is that, as it doesn't need a power source, it has reduced dimensions, thus allowing it to be implanted in the animal's body. In addition, microchips have a form of application that guarantees good information capture, making them easier to use, even in the field (Nazareno et al. 2014).

There are now microchips on the market which, in addition to individual identification, allow percutaneous thermal sensing (PTSM), without the need to take the horse out of the stable or contain it in the field to take temperature measurements. This type of microchip has proven to be useful and easy to use, and the technique is substantially faster than a digital

rectal thermometer. In addition, it allows for a more accurate reading compared to the traditional method. This approach also makes it possible to measure the number of times that an animal went to the feed and water trough.

4.2.2 Movement evaluation

In order to determine whether a person walking down the street is a stranger, the human brain needs to synchronize several processes to reach a conclusion. First, it needs to receive the image through the cornea, which is then sent to the inner lens of the eye and transformed into electrical impulses that are carried by the optic nerve to the brain. In the brain, the information is processed and transformed into information, creating a recognition and identification system (Back and Clayton, 2002).

AI systems can use the same method to learn to process, identify and report an equine's gait and thus determine possible lameness (Lawson, A. L. et al, 2020).

The sum of individual data, forage consumption, water intake, body temperature and gait assessment, collected by the sensors and cameras, can, after being processed, subsidize a database and issue alerts via communication systems, such as Short Message Service (SMS), messaging platforms or emails, any significant changes in individual animal patterns, to owners and veterinarians.

In the equine industry, the Inertial Measurement Unit (IMU) is fundamentally useful for assessing lameness in horses. It is an inertial guidance system used in the aerospace and maritime industries and has been adapted to meet the needs of horse breeding (Byström, et al. 2023).

Lameness and gait impairment can be easily identified in horses with severe symptoms, but milder signs require more accurate observation by veterinary professionals, which is a simple procedure (Stashak, 2022). The identification of lameness in an equine involves simultaneous observation of the forelimbs and hind limbs. When a forelimb is affected by lameness, the head is raised when the affected limb touches the ground and lowered when the healthy limb descends to the ground. When the lesion is on the hind limb, the croup of the affected side rises to support the injured limb and descends to support the healthy limb (Ferrari, et al. 2011).

The use of computer vision to identify lameness in horses is entirely possible, as differences in gait can be identified, however subtle, and measured (Byström, et al. 2023).

The use of automated systems in veterinary practice, animal behavior assessment and reproduction systems has increased, with an emphasis on the use of machine vision that associates image capture sensors with algorithms, using AI components, Machine Learning

and framework tools (Kamilaris 2018; Neethirajan 2020; Mathis, 2020), have been presented as valuable options in animal health management, enabling the veterinarian to act as quickly as possible in the face of the first signs of a disease.

This technology makes it possible to identify when an equine is showing lameness. According to Feuser (2022) the technology involved for this purpose includes Deep Learning, Pose Estimation and Reference Point Selection.

In veterinary science, deep learning is already being used in several areas, offering the possibility of improving behavioral studies and in the development of a pain detection model for horses (Mathis et al, 2018, KII, N. et al. 2020).

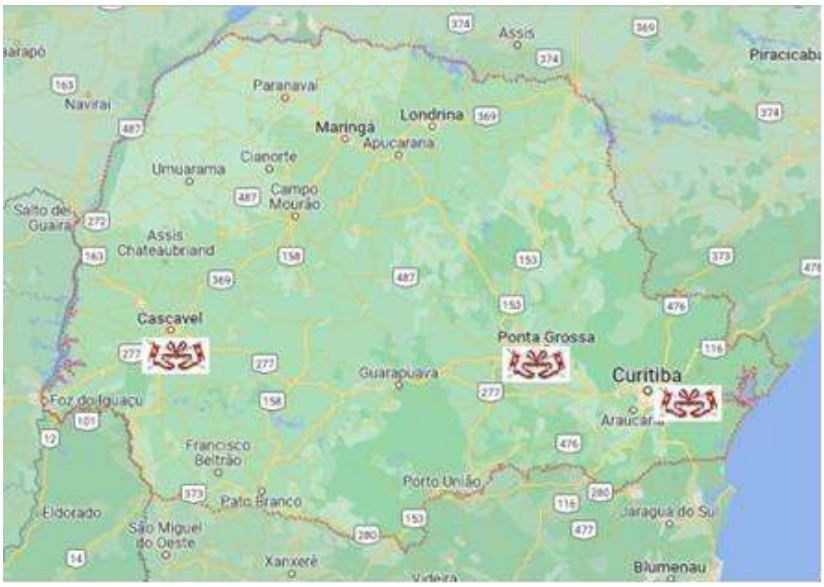
Pose Estimation makes it possible to track and record the movement of animals without having to attach any markers or sensors to the animal's body (Mathis et al, 2018). Currently there are programs such as DeepLabCut used to train Deep Learning, with only approximately 200 images, much less than previous programs that required 25,000 datasets, and for the program's algorithm to be able to predict and mark parts of the horse's body with an accuracy compared to the results achieved in experiments with humans (Andriluka, M, et al. 2014; Mathis et al. 2018).

4.3 USE OF AI IN REMOTE MONITORING OF EQUINE HEALTH IN THE PMPR

The PMPR's equine herd consists of 155 horses distributed in the categories of adult animals, breeding animals (male and female), foals and seniors, allocated to the Curitiba (RPMon), Ponta Grossa (1o.BPM) and Cascavel (5(o.) BPM) regions, as shown in figure 1. Veterinary care for these animals is provided by the PMPR's Veterinary Center, which currently has no veterinarians from the veterinary officer cadre, but two civilian veterinarians and one military veterinarian from the Military Police Officer Cadre (QOPM). Considering the number of horses, the use of technological tools is of the utmost importance in order to monitor the health status of the horses and provide a prompt response to the manifestation of diseases in their early stages.

Figure 1

Distribution of the PMPR's equine herd in the state of Paraná



Source: Authors (2023)

Using software and hardware currently available on the market, it is fully possible to remotely monitor the health of horses using AI. Initially, the animals to be monitored must be implanted subcutaneously with a thermal microchip, which has the technological capacity to continuously measure the animal's body temperature (figure 2).

Figure 2

Microchip



Source: www.vetquality.com.br (2023)

This information can be captured by readers installed next to the stalls and feeders, which measure body temperature, identify the animal and transmit it every time the animal goes to feed or drink water, thus recording the number of times the animal has eaten or drunk in a period of time stipulated by the animal's owners system operators and, in this way, it is possible to capture three fundamental pieces of information that can point to the early stages of a disease.

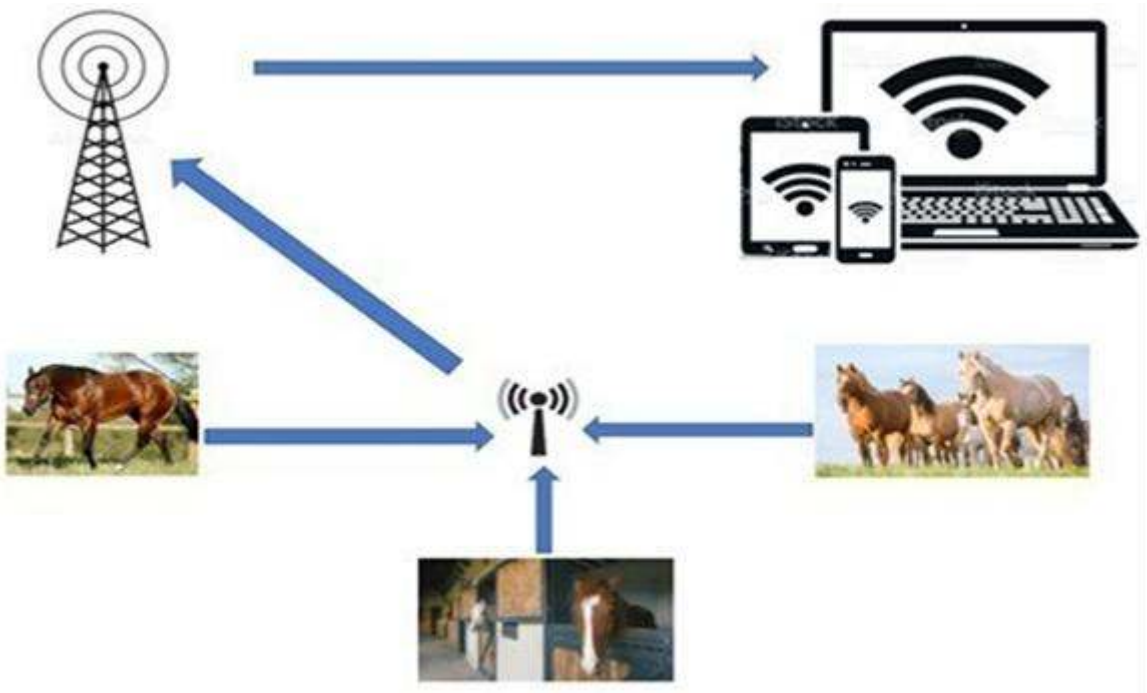
By measuring the number of times an equine has drunk and/or eaten, it can also assess the presence of polyphagia or anorexia, combined or not with adipsia or polydipsia, and by collecting information on body temperature, this information can be analyzed by an

AI, which will cross-reference environmental information, time spent in the stall and individual information (gender, breed, age and veterinary history).

After the analysis, if any changes are detected, the AI will trigger alerts to the people previously listed in the system (figure 4), monitoring which can cover a previously stipulated period of time, for seven days a week, information on that individual, and at the end of the period, it will issue a daily report on the squad.

Figure 3

Remote health monitoring of horses



Source: The author (2023)

In addition to the three factors to be monitored, another source of information can be added, in this case, the manifestation of lameness, with the use of smartcams (cameras), which, connected to the system, can capture information about the gait pattern of the patient and assess whether the animal is showing lameness and, in this way, inform those responsible, who can take action to preserve the equine's state of health, preventing it from being removed from its usual activities or, if this is necessary, due to prompt intervention, the time will be shorter and resources will be saved.

5 METHODOLOGY

The methodology applied was to research literature and websites related to the topic and to send questionnaires to private and public herd managers (immunobiological research

and production centers, remounting stations and military units) in Brazil, Portugal and Germany.

In the context of researching the literature and websites, the aim was to verify the importance of horses in economic and social terms, in the global and Brazilian spheres, their role in public safety and the technologies available on the market for remote health monitoring of horses mediated by the use of AI.

The aim of using questionnaires with the equine community was to check the market's perception, from a health point of view, of a technological proposal that allows immediate action to be taken when the first clinical signs of a disease appear.

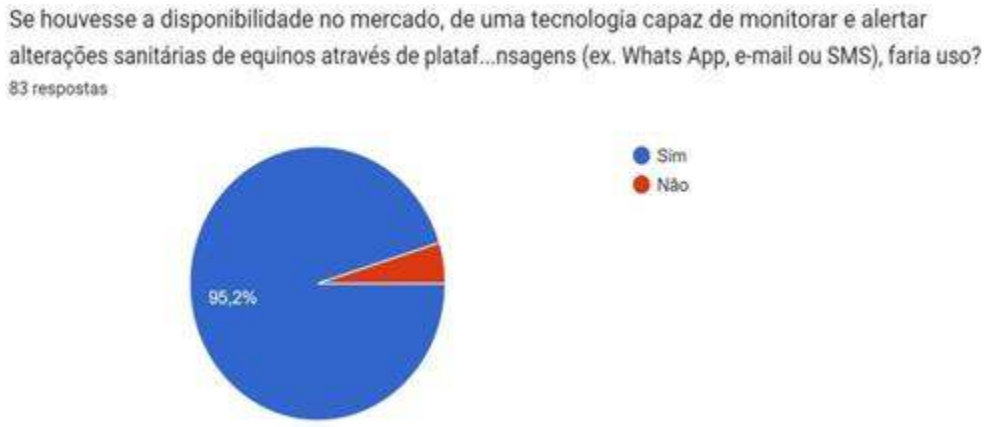
6 DATA ANALYSIS AND DISCUSSION

Research into possible equipment for a remote equine health monitoring system clearly shows that the market offers possible hardware and software for the composition of the proposal, specifically the software can be adapted or even developed to meet the demands of the proposal, with items from the national technology park.

Analysis of the responses to questionnaires distributed to professionals involved in equine management in Germany, Brazil, the USA and Portugal showed that the equine market is interested in the daily need for proper management within the pillars of animal welfare (figure 4).

Figure 4

Interest in equine health monitoring technology



Source: Author (2023)

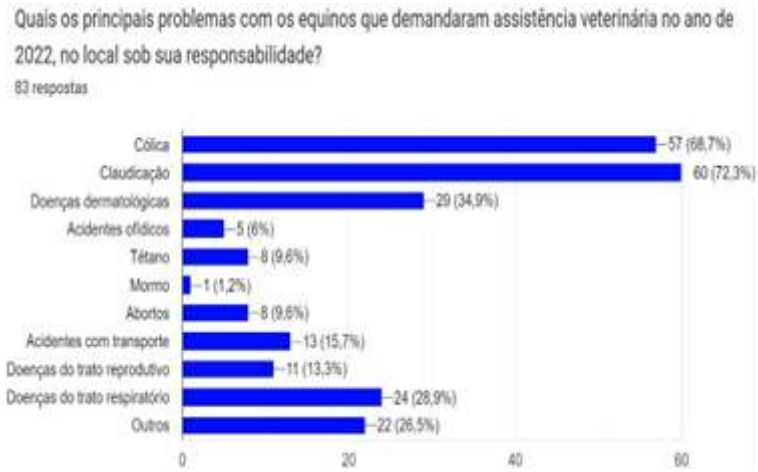
This interest is directly in line with the major diseases found in herds in the countries surveyed (graph 2), "where" among the eleven options presented, three of the top four responses are capable of being detected at an early stage already at the first signs, lameness being the most common, which, when manifested in the first few hours, can be fully detected

by smartcans and then immediately inform those responsible that a particular equine is showing signs of locomotor system impairment, thus enabling prompt intervention.

Next, the survey points out that colic syndrome is, for those interviewed, a disease that has a high incidence in livestock. Among the main clinical signs, inappetence is the main one (Oliveira, 2022), a manifestation that can be detected quickly through remote monitoring. Such a disease can start in the early hours of the morning, for example, and only be identified hours later when it is checked by an employee, a time that can be crucial for an adequate response. As soon as the system identifies a break in the animal's eating or drinking routine, it will send out a warning signal, allowing prompt intervention. Other important diseases were pointed out by those surveyed, which are also likely to have their first clinical signs detected through remote equine health monitoring: snakebite accidents, tetanus, respiratory diseases, glanders, diseases of the reproductive tract and diseases of the respiratory tract.

Figure 5

Diseases that affected the interviewees' livestock



Source: Author (2023)

The results of the questionnaire survey showed that 37.3% of professionals work with equines used in public security, animals which in general terms follow a strict prophylactic schedule as a way of preserving one of the most important areas of equine animal welfare, the area of health, thus allowing the application of a working week of up to thirty-five hours, an exceptional environment for the application of the remote health monitoring system.

During the survey, it was also found that the majority of those responsible (33.7%) have more than a hundred animals under their charge, coupled with the fact that 79.5% of the horses are distributed in paddocks and stalls, which requires a large number of employees to care for them and check their health on a daily basis, conditions which are favorable for a disease to appear and only be observed when the signs are visibly evident,

such as severe lameness, weight loss and social isolation due to the animal not being able to keep up with the movement of the herd because it is affected by some illness, factors which can be aggravated if the event occurs under certain administrative conditions, such as weekends, holidays, the end of the year, where the number of employees is generally reduced, or a change and/or lack of employees.

Two positive factors that the survey points to are the fact that 61.4% of the properties already have some kind of camera and that 95.2% of those responsible expressed an interest in acquiring a remote equine health monitoring system, despite the fact that 72.3% do not have any herd management software, thus demonstrating the need for training. Having a camera monitoring system shows that the farms already have some kind of infrastructure for installing equipment to physically support the system. The interest shown in technology that helps with health management shows that the sector is receptive to new proposals for maintaining the animals' state of health, and that awareness of issues related to animal welfare in horses is already a practical reality.

7 FINAL CONSIDERATIONS

According to Alves (2019), scientifically the term welfare refers to a "state" in which the animal is in harmony with the environment in which it lives. As a public entity, the PMPR has a legal obligation to provide all the assistance so that the equines under the responsibility of the corporation receive the proper management as advocated by the concept of animal welfare, and its agents have a moral and ethical responsibility to provide the best conditions for a dignified existence for such animals.

These responsibilities include a professional attitude at all times when the animal is under the responsibility of the public agent, when the application of the end activity provides the best material to be used (saddlery kit), Personal Protective Equipment (PPE) for application in Restoration and Maintenance of Public Order (RMOP) operations, adequate transportation, and in the field of veterinary management, drawing up a food matrix that is suitable for the activity in which the equine is used, organizing a prophylactic calendar, shoeing, and keeping up with the development of science and technology, in order to provide the best living conditions for the animal. Within these concepts, this work, far from exhausting the subject, has presented a viable proposal for real-time monitoring of the state of health of the PMPR's equines, which is Remote Equine Health Monitoring, a technological option that will make it possible to mitigate the shortages of Veterinary Officers, making it possible to anticipate veterinary care for diseases in their early stages before their progress reaches levels where reversal can only happen at a high financial cost in treatment and labor

expenditure for monitoring, if not euthanasia as a result of irreversible health conditions incompatible with life.

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