Telemedicine AI App for Prediction of Pets Joint Diseases

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Abstract Due to changes in lifestyles such as an increase in single-person households and the spread of Corona 19, the number of families with companion animals is increasing. However, since companion animals cannot communicate with language, measures for diseases or pain that cannot be seen with the naked eye are inevitably insufficient. Among them, bone and joint disease affects the movement of companion animals, and better treatment is possible if the joint disease can be detected in advance in the stage before it worsens. In this paper, we intend to design a smartphone app based on 5G communication that can diagnose the presence and possibility of bone joint disease in companion animals. The Smarteck app takes photos of the back, side, and front of the dog on a smartphone connected via 5G mobile communication and uses the photographed photos and videos to have joint abnormalities such as patellar dislocation, hip dislocation, and cruciate ligament rupture. It will be designed to analyze and judge the presence of joint abnormalities through artificial intelligence (AI) machine learning. The Smarteck app is designed to identify joint disease abnormalities and possible conditions and provide joint disease information and treatment recommendations to dog guardian.

Keywords App · Artificial intelligence (AI) · Big data · Diagnosis · Smartphone · 5G mobile communication

1 Introduction

With the development of the 4th industrial revolution technology, the use of smartphones through 5G communication is becoming popular. In addition, 5G communication smartphones are advancing based on AI that executes AR VR through
high-speed video transmission and execution in real time and performs human tasks such as real-time map route search, mobile e-commerce, and interpretation. In particular, due to the COVID-19 PANDEMIC incident in August 2020, there is a national support and social demand for non-face-to-face telemedicine using 5G communication smartphones.

As more and more people recognize companion animals as their families, interest in treating companion animals’ diseases is also increasing. If non-face-to-face telemedicine can be used to treat pet diseases, it will be possible to block COVID-19 infection pathways that can occur face-to-face, thereby preventing COVID-19.

Since companion animals and guardians cannot communicate in human language, measures for diseases or pain that cannot be seen with the naked eye are inevitably insufficient. Among the diseases of companion animals, joint disease is a disease that affects the movement of companion animals. There may be a congenital joint abnormality, or it may be a disease caused by an acquired cause. If the caregiver can detect these joint diseases in advance, I think that the quality of life of the companion animal will improve and the happiness index of the caregivers will increase by selecting treatment at an appropriate time.

In this paper, we intend to design an AI smartphone app that can diagnose and predict the presence and possibility of joint disease in companion animals. The name of the app was named Smarteck by combining the English word “Smart” and “Check”.

Smarteck App uses standards and data from professional veterinarians with more than 20 years of clinical experience. We will build big data and store it in the cloud.

After running the Smarteck app on your smartphone, take photos or videos of the back, side, and front of your dog, and match the photographed joint photos with normal joint photos to determine the presence of joint abnormalities such as patella dislocation, hip dislocation, and cruciate ligament rupture.

The Smarteck app is designed to determine the presence of joint abnormalities and joint diseases and the probability of diseases of the dog, and to recommend related treatments such as disease-related information, care method, and treatment timing to the companion animal.

2 Related Studies

2.1 Machine Learning

Machine learning, one of the artificial intelligence technologies, came into the 2000s and began to gain attention again. It is to change the parameters or structure of a system so that computers can perform the same or similar tasks more efficiently through experience and learning, and to create algorithms that use what they already know to infer what they don’t know [1]. Machine learning methods can be broadly divided into (1) supervised learning, (2) unsupervised learning, (3) reinforcement learning.
learning, and (4) semi-supervised learning which is the middle between supervised learning and unsupervised learning.

Supervised learning is a method of injecting data composed of pairs of problems and answers into a computer to learn, so that when a similar new problem is given, the answer can be found. Unsupervised learning is a method of training computers to find answers by themselves and solve problems. Unsupervised learning includes clustering to classify data with similar characteristics and learning association rules to find relationships between characteristics in a large amount of data. Reinforcement Learning is likened to the process of learning about the world when a human baby is born. It is a method of finding a goal through the learning process, and a method of determining a policy so that the reward is maximized through actions and rewards accordingly in a specific environment.

In this paper, a dog joint abnormality diagnosis system app is designed using a data mining pattern recognition method to predict joint diseases in companion animals.

Figure 1 shows the components and processing process of the pattern recognition system. Pattern recognition systems are generally processed through five processes.

First, the object is measured in the real world, and the measured value is processed to some extent to make it into a desired shape or normalized through a preprocessing process that extracts a specific part.

After that, it is evaluated using an algorithm suitable for the type of problem, and to verify that the evaluation is successful, it is verified through a model selection process such as cross-validation or bootstrap, and results are derived [2].

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![Fig. 1 Pattern recognition system components and processing](image-url)
The Smarteck app in this paper is designed to be used in the steps before visiting a veterinary hospital by analyzing dog joint photos and videos to determine joint disease. It is necessary to build big data of dog joint photos and videos for analysis and determination of the disease.

2.2 Dog Joint Disease

Patella dislocation: refers to a disease that comes out of or out of the patella lying on the trochanter, and can be classified into 1st, 2nd, 3rd and 4th stages depending on the degree and pattern of the dislocation. In the first stage, dislocation occurs only when the patella is pushed inward or outward. Stage 2 can be intermittently dislocated even when the patella is bent and stretched. However, it refers to a state in which the patella returns to the normal position when the knee joint is moved to the normal position or the knee joint is moved again. In stage 3, the patella is mostly dislocated. Stage 4 means that the patella is permanently dislocated and cannot be moved to its normal position. Most of the causes of patella dislocation are related to musculoskeletal abnormalities such as medial quadriceps dislocation, the femur twisting and bending outward, the femur end abnormally formed, the rotation of the knee joint unstable, and the presence of deformities in the tibia [3].

Hip Dislocation: Hip dislocation is a disease that must be treated as soon as possible to prevent continuous damage to the soft tissue surrounding the hip and degeneration of the articular cartilage. When the hip joint is dislocated, it shows claudication in which weight support is impossible. When hip dislocation occurs, there is a difference in the length of the legs of both hind legs. The anterior dorsal displacement is shorter in the affected leg than in the normal leg and is reversed in the abdominal dislocation [4].

Cruciate ligament rupture: The cruciate ligament is the ligament that connects the femur and tibia and serves to limit the anterior and posterior movement of these two bones. It consists of an anterior cruciate ligament and a posterior cruciate ligament. Cruciate ligament injury means that the ligament is partially or completely torn, or the ligament that is attached to the bone is detached. If the anterior cruciate ligament is partially ruptured, a mild pain response or lameness may be observed. Partial rupture can proceed as a complete rupture over time [5].

Shoulder dislocation: It is not a common disease, but it refers to the separation of the humerus and scapula due to loss or damage to a part of the structure supporting the joint. It may be caused by trauma or may be congenital. Dislocation occurs when the biceps tendon and the forelimb ligaments above the inner and outer joints are torn or missing. He cannot support the weight of the dislocated leg and intermittently walks with his leg bent [6].
3 Dog Joint Disease AI Machine Learning Design

3.1 Big Data Analysis and AI System Design by Dog Joint Disease

In veterinary hospitals, treatment related to dog joint disease is generally conducted in the order of “interview with guardian → gait observation → pain area promotion → radiography → radiation reading → diagnosis with veterinary opinion”.

In this paper, we use the pattern recognition method of data mining and design an AI app for dog joint abnormality diagnosis system so that companion animal joint disease can be predicted.

Table 1 shows the comparison between normal joint and medial and lateral patella dislocation or hip dislocation disease suspicious shape for data construction.

The probabilities in the left column of Table 1 can be classified by the point used when determining the presence or absence of a disease and the angle of the open joint of the point, and it is designed to be built into cloud big data through supervised learning of AI machine learning.

Points A and D denote the hip joint, B and E denote both knee joints, and C and F denote both ankle joints. In a normal dog joint arrangement (green line) without joint disease, the three joints above, hip joint, knee joint, and ankle joint lie on a nearly straight line. However, the joint arrangement (red line) of a dog suffering from joint disease goes out of line. The green line in Table 1 represents the normal arrangement, and the red line represents the joint arrangement of the diseased dog.

The angle represented by the line in Table 1 is represented by an equation in Table 2.

| Disease Percentage | Medial patella dislocation (one side, two sides) | Lateral patella dislocation (one side, two sides) | Hip dislocation |
|--------------------|-----------------------------------------------|-----------------------------------------------|----------------|
| 50% ~ 90%          | ![Medial Patella Dislocation](image1)           | ![Lateral Patella Dislocation](image2)        | ![Hip Dislocation](image3) |

Table 1 Comparison of shapes for building big data by joint disease
Table 2 Parameters for analyzing the presence or absence of joint disease (angle measurement points)

\[ f(s) = X_L(\theta_{L1M}, \theta_{L3M}) + X_L(\theta_{R1M}, \theta_{R3M}) + X_L(\theta_{L1M}, \theta_{R1M}) + X_L(\theta_{R1M}, \theta_{R3M}) + X_L(\theta_{L1M}, \theta_{L3M}) + X_L(\theta_{R1M}, \theta_{R3M}) \]

- \( \theta_{L1M} \) = angle of red line AB and green line AB
- \( \theta_{L3M} \) = angle of red line BC and green line BC
- \( \theta_{R1M} \) = angle of red line DE and green line DE
- \( \theta_{R3M} \) = angle of red line DE and green line DE

3.2 Smarteck App Machine Learning Design

Design a smart app to be used in 5G communication smartphones. As a first step in Smarteck App, we design an AI machine learning method using a rule-based expert system. Figure 2 describes the five stages of a rule-based expert system. It can be designed in 5 steps as shown in Fig. 2.

As shown in Fig. 2, a rule-based expert system is built based on expert knowledge of veterinarians with more than 20 years of clinical practice. There may be some
differences depending on the dog species, but in general, dogs consider the joint state in which the hip joint, knee joint, and ankle joint (ankle joint) are arranged in a straight line as a normal model. Figure 3 shows the normal joint position and arrangement. A and D represent the hip joint, B and E represent the knee joint, and C and F represent the ankle joint.

First, these three joint points are determined as a reference, and the position and arrangement are compared and analyzed to see how they differ from the normal appearance. For example, in dogs with a patella dislocation, the knee joint (points B, E) is pushed inward or outward, causing a deformation in the shape of the leg. In dogs with hip dysplasia or hip dislocation, the arrangement of the hip, knee and ankle joints deviated from a straight line when standing or walking due to a variation of the hip joints (points A, D).

Establish the data so far as a data base, and standardize the data format and contents by assigning a format to the data for each disease label. Based on the standardized data format and knowledge, it makes rules to train computers. Table 3 shows how the rule was applied to draw conclusions by implementing this rule as a rule to be used when judging unilateral patella dislocation and creating a chain of reasoning.

The big data on the patella dislocation and hip joint dislocation constructed in 3-1 is used by a computer to learn big data through machine learning. DB and machine learning compare and read the learned results, and access values of 50% or more and 99% or less through error judgment (false detection) and excessive judgment (overdetection).

The standardized data base is stored in the cloud through the Internet. The stored cloud information is subjected to AI machine learning supervised learning to generate

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**Fig. 3** Dog normal joint location and arrangement
Table 3  Rules to use for smarteck App

| IF | Both hip joints of the dog coincide with points A and D. |
|----|--------------------------------------------------------|
| AND | The dog’s left patella is located to the left of point B. |
| AND | The dog’s left ankle joint is located to the right of point C. |
| AND | The dog’s right patella coincides with point E. |
| AND | The dog’s right ankle joint coincides with point F. |
| THEN | The dog may have a unilateral patella dislocation. |

data for recognition and identification of joint diseases in dogs. Receives images of dog joint disease from the smartphone smart phone using 5G communication. Joint disease images are recognized by AI machine learning, identified, and transmitted to smart phone smart app.

Figure 4 is a flow chart of Smarteck App. Run the Smarteck app on your smartphone. Take photos or videos based on the shape of the dog’s joints, and determine the presence or absence of a disease through the Smarteck app. When it is determined that there is a disease by removing error judgment and excessive judgment and selecting AI judgment, information and treatment related to disease and care are recommended.

3.3  5G Communication Design on Smarteck App

Figure 5 shows the communication design of Smarteck App.

The higher the quality of videos and photos, which are the data necessary for diagnosis, the more accurate it is to determine the presence or absence of a disease. To this end, it utilizes large-capacity, high-speed transmission of 5G communication, and improves the efficiency of image recognition and judgment on joint diseases with the big data of the cloud and the learning result of AI machine learning.
Fig. 4 Smarteck flowchart

Fig. 5 Smarteck communication system
4 Design of Smarteck App for Determining the Presence of Joint Disease in Dogs

Install the Smarteck app on a 5G communication smartphone, sign up as a member, log in, and run the app. Figure 6 is the full screen configuration of the Smarteck app. After logging into the smartphone app, photograph the dog and scan the joint shape. AI machine learning compares with the supervised learning data, reads whether the joint points match, and displays the read result on the screen.

As shown in Fig. 7, after running the Smarteck app on a 5G communication smartphone, access the camera app and take a picture or video of the dog. When taking pictures, take pictures so that both hind legs come out correctly. After shooting, upload photos and videos to the Smarteck app.

4.1 Shooting Mode

4.2 Scan Mode

The captured two hind legs are displayed on the screen and displayed by touching the app as shown in Fig. 8 based on the data of the hip joint, knee joint, and ankle joint of AI machine learning that are the standard for comparative analysis.
Fig. 7  Shooting mode

Fig. 8  Scan mode
4.3 **AI Readout Mode**

The information learned in AI machine learning is compared with the photographed joints. Compare and analyze the normal joint model and the point taken by touching in Fig. 8 as the pattern matching method.

Figure 9 is a screen under comparative analysis of dog joint disease.

4.4 **Result Mode**

The screen displays 4 items as the result of readout.

- What percentage does the reading match the shape of the normal joint?
- What percentage is the likelihood of having joint disease?
- What are your recommendations?
- Click for information on related joint diseases

Figure 10 is the result screen of the Smarteck app.
5 Conclusion

There is a social demand for non-face-to-face telemedicine with COVID-19 PANDMIC. In this paper, in order to solve the frustration of being unable to communicate about companion animal diseases through non-face-to-face telemedicine, we designed an AI machine learning method for predicting dog joint disease through the AI app Smarteck on a 5G communication smartphone.

Save the standardized data base in the cloud. Cloud information is based on AI machine learning supervised learning, which creates the base data for recognition and discrimination of joint diseases in dogs. Computers learn normalized and standardized big data for patella dislocation and hip dislocation of dogs using AI machine learning. Through 5G communication, images of dog joint diseases are transmitted from Smarteck App. Joint disease images are recognized by AI machine learning, identified, and transmitted to smart phone smart app. The learned results are compared and read by a computer using AI DB and machine learning supervised learning, and error judgment and excessive judgment are eliminated by AI deep learning, and the disease diagnosis probability is 50% or more and 99% value is approached.

Run the Smarteck app on your smartphone. A photo or video is taken based on the dog’s joint shape, and the presence or absence of a disease is determined through the Smarteck app. It was designed to remove error judgment and excessive judgment, select AI judgment, and recommend disease and care-related information and treatment when it is judged that there is a disease.
While designing the Smarteck app, it was found that research data on the comparative angle of the normal joint position of a companion animal and the position of a diseased joint were insufficient. It is necessary to study future comparative angles by using AI deep learning technology for photos and videos that will be obtained through the Smarteck app.

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