A Survey on the Latest Developed Emotion Recognition and Legged Robots

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Abstract

As robots are being applied to increasing industrial fields, they began to hold the main position in dealing with an amount of different practical tasks gradually. To figure out certain relationships between robots and humans and how legged robots can achieve adaptive behavior, in this paper, I analyzed a couple of principles of recently designed emotion recognition and legged robots by comparing and summarizing the methods and functions of the trains of thought of two kinds of newly designed robots-Emotion Recognition and Legged Robots. Legs are nothing new for humans or animals, but fitting a robot with legs and making them perform functions similar to humans' legs is a complex problem. As we can see from the fact that babies learn to walk and the learning curve involved, which indicates that even humans with good motor intelligence spend years learning to walk when they are very young, it's not difficult to imagine the difficulty of creating legs for a robot and training it to walk properly. Meanwhile, Emotional recognition is the cornerstone of Human-Robot Interaction, and its main task is to establish an intelligent computing system that can analyze and recognize human emotions from speech, text, video, and other modes to realize humanized communication between humans and machines, which is of great theoretical significance and practical application value. The search results on these robots can help to illustrate some specific task execution procedures and serve as a motivation to better understand the design methods of robot learning.

Keywords: Robotics, Artificial Intelligence, Emotional Recognition, Human-Robot

Interaction, Adaptive Legged Robot, Signal processing, low-pass filter

Introduction

Notwithstanding the enormous potentials of 5G networks and their expected evolution,significant efforts are already being devoted to designing a future generation of networks,namely Sixth Generation(6G),which is expected to create a cyber-physical continuum between the connected physical world of senses,actions,and experiences and its programmable digital representation[1]. In this way,we can utilize such network support combined with various wireless devices to better control advanced robots such as emotional recognition robots,adaptive legged robot (flexible robot technology),and unmanned aerial vehicles(autonomous driving technology).The application of each kind of robots is pretty meaningful. For instance,as an important topic in the field of artificial intelligence, emotion recognition can help computers intelligently recognize human emotions and make Human-Robot Interaction more friendly.Legged robot is a critical field of mobile robotics thanks to its adaptability on sophisticated and irregular ground.Achieving versatile robot locomotion requires motor skills that can adapt to previously unseen situations[2].Consequently,providing the legged robot with more useful environmental information conveyed by electric signals is a crucial issue,particularly for heavy-duty legged robots(HLLR) requiring stable locomotion[3].Furthermore,as for unmanned aerial vehicles(UAV),whether it is to assist traffic, supervision of scenic spots, or tourism aerial photography, commercial performances, UAV have shown great value and charm to people.

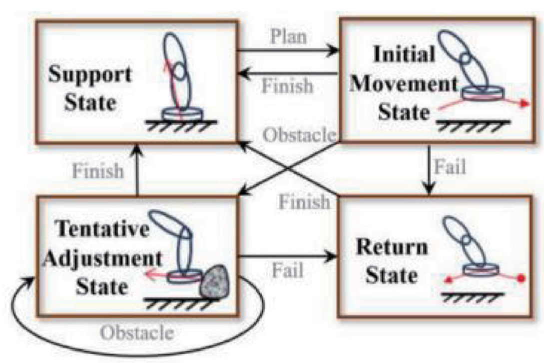

Figure 1[3].The finite state machine designed for HLLR's force sensing motion,which is inspired by the three states of the elephant leg(support state,movement state and adjustment state).

Although extensive research has been carried out in the field of legged robots, researchers are still working to build legged robots that can simulate human walking or the movement of any animal.The traditional wheeled robot has poor obstacle crossing ability, poor terrain adaptation ability, low turning efficiency, large turning radius, and it is easy to slip because it is not smooth enough. Specifically,wheeled service robots used in restaurants have high terrain requirements and may require human assistance, and cannot achieve complete intelligent services.The tracked robot also has high requirements for terrain, and can do nothing about the terrain with a large highland drop or some irregular regions.It is not as flexible and convenient as the legged robot. Legged robots can almost adapt to a variety of complex terrain and cross various obstacles.It can also achieve flexible movement which is comparatively free and stable. Legged robots are dynamically stable and require complex control algorithms to balance them while standing or doing actions.For instance, “ASIMO” from Honda and “QRIO” from SONY are both excellent examples of legged robots that can walk, run, stand and even dance. These robots maintain stability by planning their steps.

With the rapid development of artificial intelligence, the number of mobile applications and start-ups in emotional recognition has increased significantly, and mobile applications are currently mainly used in business negotiations, health care, distance education, safe driving, and public services. For example, the dialogue emotion recognition platform developed by Baidu can automatically detect the emotional characteristics contained in the users’ daily dialogue texts, and the artificial intelligence platform developed by MegVII Technology can already get seven types of emotions such as anger, disgust, and panic through input pictures. Additionally,the dynamic emotion recognition system produced by Shenzhen Anshibao Technology Company can be used for emotional early warning.But to date, most legged robots still lack the ability to recover quickly from falls and generate adaptive movements to deal with unexpected situations.

Studying Human-Robot Interaction over time can provide insights into what really happens when a robot becomes part of people’s everyday lives.When the robot shares the daily experiences with the person through the diary,the relationship between the robot and people are more likely to strengthened.For example,SHARP’S RoBoHoN can remember the events of the day like a diary written by humans when people talk to him[4].To be specific,as the corporation described,when you talk to RoBoHoN,which lives with you together,you can relax your mind naturally by interacting with it in many ways such as traveling,telephone recording and exercising together[5]. Such fantastic robots are able to make our life more active and entertaining.Moreover,there are other robots like Robo-Barista,which can interact with people and serve up the requested coffee via natural language interaction. This emulates a robot that you might find in a cafe,acting as a barista,with whom regular customers would interact periodically over a long period of time[6].

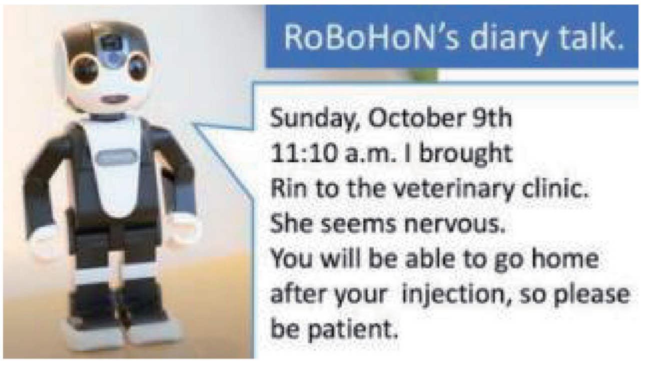

Figure 2[4]. An example of diary implementation by communication robots on the market in Japan (RoBoHoN).The robot can read out the diary generated by itself.

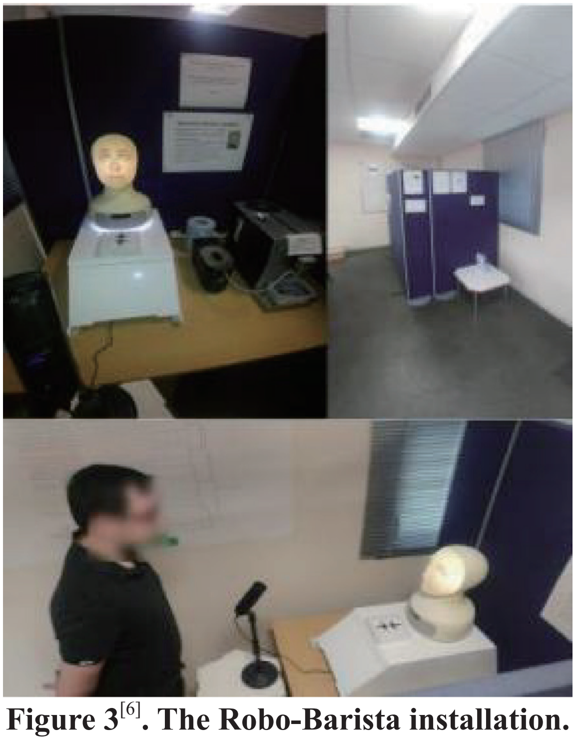

Figure 3[6]. The Robo-Barista installation. Top left:inside the booth.Top right:the booth situated in departmental common room. Bottom:the user who is interacting with Robo-Barista.

Thus,through learning these latest developed robots,the up-to-date progress and quite practical applications of robots associated with different signal processing designs on different fields can be clearer.At present, although there have been robots related to emotion recognition that have improved humans' sense of life experience to a certain extent and alleviated the shortage of social demand resources, the related technologies have not been fully developed and have not been able to carry out large-scale promotion in the world.

This study aims to summarize the functions and principles of a couple of newly developed robots.

A Method of Emotion Recognition-Diary Writing System

In terms of robots that can generate diaries automatically,which are designed to improve the quality of human-robot communication,Aiko Ichikura led the research group in the university of Tokyo to propose an automatic diary generation system that used information from past joint experiences with the aim of increasing the favorability of humans for robots through shared experiences between humans and robots.A large-scale language model was applied to strengthen the verbalization of the robot's memory.In an experiment,a robot and a human went for a walk and generated a diary with interaction and dialogue history,which was similar to RoBoHoN's diary talk.As the model fails to have memories of experiences,it is able to generate a diary by receiving information from joint experiences[7].

The diary system consists of the Memorizing System and the Remembering System.The Memorizing System has access to information from joint experiences with people,and the Remembering System generates a diary from the information acquired through joint experiences. The integration of the two systems is considered as the innovation point.

What is shown in a diary is a subjective story,a kind of narrative.The narrative approach uses narrative as a methodology,which originates from the storytelling methodology of Bruner.[8][9][10]It highlights the significance of the narrator's experience.When the robot aims to make a diary,it tries to choose the scenes that have "meaning" in the entire experience from the robot's point of view instead of a periodic record of events or a list(namely scenery,names of events,names of related objects,etc.) The memorized information is processed in the sequence of selecting,describing and summarizing to generate premise,description,and direction sentences.The generated sentences are then input to GPT-3[11] to obtain the final output,the diary.

The study demonstrated the effectiveness of the diary generation system by examining whether the generated diaries improved human favorability toward the robot both quantitatively and qualitatively. In order to enhance the relationship between humans and robots through the sharing of experiences, the system presents the robot's situational narrative as a diary using perceptual and linguistic information obtained from shared experiences interacting at the physical and verbal levels. In order to quantitatively and qualitatively test whether the diary generated by the proposed system is conducive to improving the liking of the robot, this experiment generated a diary, including the interaction and interaction history between the researcher and the robot during walking, and examined the change of people's impression of the robot formed by the diary and people's liking of the diary based on the generated diary contents.

At the same time, the research has shown that using diaries to present shared experiences between humans and robots can make people feel more "comfortable". This suggests that verbalizing and presenting memories of events can deepen communication and bonding between humans and robots. In addition, the information in the diary about the physical and verbal interactions during the walk did trigger empathy and a relationship between the human and the robot, because the diary clearly revealed the robot's emotions, which humans were equally able to perceive. On the other hand, the study found that detailed descriptions of emotions and interactions lead to feelings of intimacy and journaling specificity in robots, but they also elicit similarities and aversions in robots, which may ruin some readers' impressions of diaries. Therefore, when robots present memories related to emotional experiences, humans usually have a good impression on these emotions of robots, thus enhancing the depth of Human-Robot Interaction. However, in some cases,it is necessary to filter the information which has been received, which means only the more important information is extracted or some redundant information is omitted.

Adaptive Legged Robot Jueying and relevant signal processing techniques

The study conducted by ChuanYu Yang[2] has obtained practical design ideas from the neural system of biological motor control. Biological studies have shown that the general motor behavior of organisms is controlled by the central nervous system (CNS), which resets the reference position of body segments, and the difference between the reference position and the actual position stimulates muscle activity to generate the appropriate force to facilitate the movement process. Since impedance control provides spring damping properties similar to the elasticity of biological muscles, the researchers apply the equilibrium point (EP) control hypothesis to generate joint torque by counteracting the equilibrium point.

The research method divides the control of the robot into two layers: the bottom layer uses torque control to configure the joint impedance of the robot and the top layer specifies a deep neural network (DNN) to generate set points for all joints to adjust posture and joint torque and establish force-environment interactions. The design of the top-level learning algorithm is the center of the robot to achieve human-like motion intelligence[2].

In this study, a hierarchical multi-expert learning framework (MELA) was used to capture a wide range of adaptive behaviors. It is a structure composed of a gated neural network, a network of eight experts (namely the control of eight basic motor skills), and a dynamic synthetic network. These structures continuously fuse DNNS into a single synthetic neural network at each time to generate the comprehensive strategy needed to move in different motion scenarios. To be specific, this machine learning is divided into two training phases, starting with pre-training of different motor skills such as recovering from a fall and trotting, followed by combined training of the three networks. During the joint training process, eight different experts are controlled by a gated neural network (which is the core of MELA's adaptive behavior), and then the joint impedance of the motor is dynamically generated by the synthetic neural network.Next,the joint impedance is used to set the joint torque and control the robot's motion state. During the movement of different scenes, the activation of the eight experts is constantly changing. In the field tests, the robot Jueying was able to traverse an uneven road made of stone, as well as a stretch of outdoor grass with the interference of human pulling. The test results show that Jueying has agile adaptability and rapid response to different environmental conditions and human disturbances, that is, it can finish smooth transition and adjustment between standing balance, trotting, turning and fall recovery.

At the same time, in terms of movement space, in order to ensure the smoothness and feasibility of robot Jueying in the actual movement process, the relevant technology of signal processing is also applied here. The researchers use a low-pass filter to simulate the frequency response characteristics of the actuator, an application known as motion filtering. Specifically, the cut-off frequency of the actuator is 5HZ. For safety considerations in the actual experiment, the researchers further adjust the cut-off frequency to 3HZ, which can restrict high-frequency actions to a certain extent. Additionally, the researchers use a first-order Butterworth filter to filter the motion and simulate the frequency response of the actual motor, helping the robot improve its performance during motion. As a result, the motion behavior within the bandwidth is smooth and smoothly executed.

Furthermore,in the study led by Wanming Yu and Chuanyu Yang,when they designed a control framework for legged locomotion,they use the Butterworth filters[12].The control framework includes a high-level behavior loop where the low-pass Butterworth filter cut-off frequency is 10Hz, and a low-level joint position loop where the low-pass Butterworth filter cut-off frequency is 4Hz.The joint level controller receives the reference position of the filtered joint, and then calculates the joint torque of 1KHz which is quite appropriate through the mathematical formula, and then controls the robot to move this. This process of promoting robot movement according to joint torque is similar to the process of Jueying controlling movement in the neural network, both of which realize the function of filtering and screening expected actions.

Conclusions

This paper briefly analyses the basic ideas, framework and methods used in the design of emotional recognition robots and adaptive legged robots. First of all, I realized a design method for diary generation in the newly developed artificial intelligence emotion recognition system, and realize that Human-robot Interaction is of great significance.As the technology of robots keeps advancing,the degree of our interaction with robots will continue to deepen. At the same time, according to the deep reinforcement learning technology covered by the adaptive legged robot, I realize the core role of the top-level algorithm in the motion process control. Moreover, the similarity of the motion control of legged robots is found in the process of further action based on the torque calculated and obtained by the feedback process of different joints. This deepens my understanding of the interaction and joint action between neural networks. And I am also aware of the important application mode and principles of low-pass filtering technology in signal processing in the process of selecting motion. In general, the technology and principles involved in controlling an intelligent robot's behavior are extensive and profound. The knowledge in many studying fields is critical in training a great robot.

In summary,the paper provides an overview of the two types of newly developed intelligent robots, which can help to understand the research methods involved in robot emotion recognition and the significance of emotion recognition for strengthening Human-Robot Interaction. And the specific application mode of deep neural network technology covered by several different effective motion modes trained by a multi-expert learning model in different environments.

Meanwhile, there are still some shortcomings in this work. For example, the calculation details involved in the selection, description, and summary process of the implementation of the Memory System of the emotion recognition robot are not detailed and sufficient. RoBoHoN's selection probability calculation method in scene selection is not fully showed, and the more detailed calculation process is not described.As for adaptive leg robots, I only have an intuitive understanding of the framework of MELA and neural networks.Thus, the details of more specific algorithms need to be further studied. In terms of the signal processing involved in the motion control process, although an effective application mode of low-pass filter in the motion control process has been learned, my understanding of the characteristic curves of various signals containing noise obtained by experiments on the robot motion process in more complex cases is not sufficient. The shortcomings mentioned above are all further work to be carried out in the future.

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