Current Status and Prospects of Robot Dog Application

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Abstract. In the era of rapid development in computer science, artificial intelligence (AI), and the Internet of Things (IoT), robotics has undergone continuous updates and iterations. People have been exploring various application areas for robots, with robotic dogs standing out prominently. These robotic dogs are highly anticipated due to their remarkable attributes of high flexibility, adaptability, and stability. They have become a powerful magnet, attracting numerous technology companies worldwide. The market prospects for robotic dogs are extremely broad, as they can be applied in areas such as companionship, rescue operations, reconnaissance, and logistics. Furthermore, they also generate significant social discourse, making research on robotic dogs highly valuable. This paper provides a brief overview of the application scenarios of robotic dogs in the domains of home companionship and natural disaster rescue. It summarizes the relevant technologies and current developments utilized in these two fields and offers a glimpse into the future applications of robotic dogs.

Keywords: Robot Dogs, Home Companionship, Disaster Rescue.

1. Introduction

The development of robot dog is inspired by the study of animal biomechanics and motion control. The earliest mechanical dogs can be traced back to the 1960s, and they have been evolving for over 60 years [1]. Scientists aim to further understand the principles of animal locomotion by studying and mimicking the walking patterns of quadruped animals. These principles are then applied to robotics technology. With the rapid advancement of various technologies such as hardware mechanics, software systems, sensors, AI, etc., robotic dogs are undergoing rapid iterations. They possess characteristics such as high dynamics, adaptability, stability, and load capacity. As a result, they can be widely applied in fields such as disaster rescue, companionship, reconnaissance, security, medical rehabilitation, agricultural manufacturing, and more [2].

This article will discuss and analyze the current development status of robotic dogs in different fields. First, the field of home companionship will be explored, followed by the domain of natural disaster rescue. The article will discuss and analyze the application scenarios, technologies employed, and current development status in each field. This analysis aims to provide valuable insights and references for the future development of robotic dogs.

2. Home companionship field

2.1. Applications of robot dogs in the field of home companionship

2.1.1 Companionship for the Elderly

In modern society, the aging population is becoming increasingly severe, placing a growing burden on society, and the issue of elderly care has received widespread attention. Meanwhile, with the development of Internet technology, companion robots, primarily based on artificial intelligence service systems, have rapidly advanced. By utilizing advanced technologies such as machine learning, natural language processing, and image recognition, these robots engage in intelligent interactions with humans and are increasingly being applied in companion-based emotional care for the elderly [3]. Among them, the emergence of intelligent robotic dogs can greatly compensate, to some extent, for the shortage of elderly care services caused by the rapid increase in the elderly population and the

scarcity of related caregivers and elderly care institutions. Children cannot be present with the elderly every day, but robotic dogs can provide companionship and emotional support to the elderly. They can communicate and interact with the elderly, allowing the elderly to experience the vitality of life and find solace in their hearts [4].

2.1.2 Companionship for Children

In terms of child companionship, robotic dogs can serve as a new generation of electronic products and offer unique advantages in child companionship and education compared to television and smartphones. In theory, they can help mitigate the negative impact of television and smartphones on time management and interaction. Firstly, in terms of interaction, robotic dogs are designed to mimic the characteristics of real dogs, such as cute appearance, wagging tails, interactive sounds, etc., which helps establish an emotional connection with children. Secondly, through algorithms and personalized customization, robotic dogs can better manage children's usage time of electronic devices [5]. Robotic dogs can also provide entertainment and interactive experiences for children. They engage with people in various ways, such as playing, performing small tasks, and learning new skills. Robotic dogs can perceive the surrounding environment through sensors and cameras and respond accordingly based on people's interactions. This interaction can enhance the fun and intimacy among family members (Figure 1).



Figure 1. Robotic dog for children [3]

2.2. Robot dog primary utilized technologies

The core technologies involved in robotic dogs span multiple dimensions, including artificial intelligence, sensors, interactive systems, engineering mechanics, and more.

2.2.1 AI Technology

AI technology enables robotic dogs to engage in natural and direct interactions with humans. Speech recognition and natural language processing techniques allow the robots to understand and respond to human language commands and conversations. This enables robotic dogs to serve as personal assistants, answering questions, providing information, and performing tasks [6].

2.2.2 Sensor Technology

As the hardware perception layer of robotic dogs, different sensors are used based on their specific functionalities. For example, installing a laser radar enables obstacle avoidance capabilities, while installing a camera enables tasks such as image recognition. Additionally, incorporating a gyroscope allows for posture correction. In summary, the perception layer of robotic dogs, similar to the human sensory system, is an essential component of these mechanical companions.

2.2.3 Robot Operating System

It manages and coordinates various components and functionalities, including scheduling rules for the sensors and facilitating collaboration among them. This allows robotic dogs to operate efficiently and accomplish a wide range of tasks.

2.3. Current status of robot dog in home companionship field

In a home environment, robotic dogs can serve as companions for lonely elderly individuals and children, providing emotional support, companionship, and interaction to help alleviate anxiety and enhance social engagement. They can play music, tell stories, remind about medication schedules, and facilitate social interaction through games and activities. Robotic dogs can also assist in monitoring home security by patrolling and detecting unusual activities, thereby providing a certain level of safety assurance.

While robotic dogs have tremendous potential as companions in the realm of home companionship, they still face several challenges. For instance, the cost of the technology remains high, and there is a need for improvement in terms of reliability and adaptability. Additionally, the ability of robotic dogs to provide emotional support is still limited, and they cannot fully replace human companionship and care.

3. Disaster search and rescue field

3.1. Applications of robot dogs in the field of disaster search and rescue

As sensor technology and artificial intelligence continue to advance, robotic dogs have found wider applications in daily life, particularly in scenarios involving unknown environments such as post-disaster rescue and terrain exploration. Quadruped robots are less affected by environmental factors such as temperature and weather, and they do not require physical resources, water sources, or shelter/resting places. This makes them highly suitable for use in hazardous environments [7]. Following disasters such as earthquakes, fires, or nuclear leaks, direct human entry can lead to severe consequences, including casualties. To avoid such situations, robotic dogs can be deployed for autonomous exploration of unknown environments, establishing environmental models, and creating maps that facilitate subsequent human operations [8]. People can also remotely control these devices to assist in terrain reconnaissance, search and rescue operations, and other scenarios. Robotic dogs can be utilized in complex terrains where wheeled or tracked robots may struggle to adapt, as shown in Figure 2, enabling them to accomplish more complex and challenging tasks [9].



Figure 2. Robotic dogs in different terrain [10]

3.2. Current status of robot dog in disaster search and rescue field

By equipping specific sensors, robotic dogs are capable of detecting and searching for vital signs of life at disaster sites, such as the sound, body temperature, or breathing of trapped individuals. They can utilize this sensor data to locate and rescue the trapped victims, providing crucial information to the rescue personnel. Robotic dogs can perform tasks through remote operation or autonomous navigation. In hazardous areas, remote operation allows for guiding search and rescue operations using real-time video feedback from the robotic dogs. This approach enhances the efficiency of search and rescue efforts while ensuring the safety of human rescue personnel.

Currently, research on robots for natural disaster rescue primarily focuses on wheeled robots. However, in complex terrains, wheeled robots have limited mobility and are unable to effectively complete exploration tasks. On the other hand, quadruped robotic dogs possess strong maneuverability and flexible movement capabilities, making them highly valuable for exploration tasks. At present, robotic dogs are in the early stages of development in the field of disaster rescue. Due to high manufacturing costs, they have not yet become widespread in the market.

4. Prospects and discussion

The recent advancements in artificial intelligence have been quite dazzling, ranging from AlphaGo, general artificial intelligence, and Life 3.0 to ChatGPT. The rapid development of AI has provided greater potential for the growth of robotic dogs in the field of home companionship [10]. Indeed, although robotic dogs are still in the early stages of the development of disaster rescue, humans expect that they will play a greater role in future sustainable progress and technological progress. They have the potential to enhance search and rescue efficiency and increase the success rate of rescue operations [11].

The patent data related to robotic dogs, as shown in Figure 3, demonstrates an upward trend over the years, reaching its peak in 2020. However, there has been a slight decline in the years 2022-2023, likely influenced by the pandemic. Nevertheless, this trend still reflects the vast potential for the continued development of robotic dogs, and an increasing number of research teams are actively engaged in studying and advancing this field.

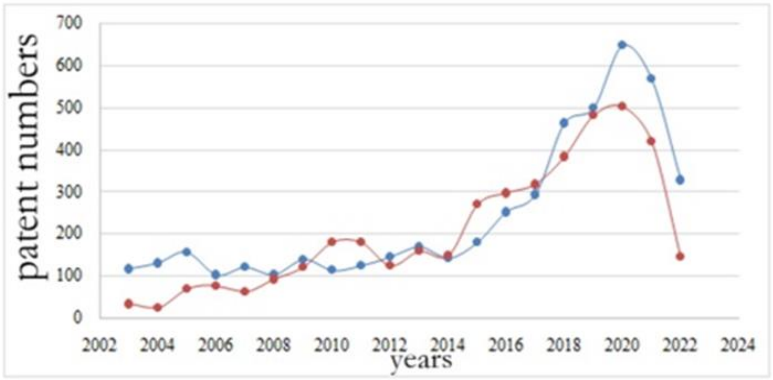


Figure 3. The trend of patent applications for robotic dogs [2]

5. Conclusion

This article discusses the current applications and technological developments of robot dogs in the fields of domestic companionship and disaster search and rescue. In the field of domestic companionship, robot dogs can provide companionship and emotional support for the elderly and children, helping to alleviate anxiety and increase social interaction. In the field of disaster search and rescue, robot dogs are capable of autonomous exploration and search in hazardous environments, providing vital information to rescue personnel and improving search and rescue efficiency and success rates. However, the commercialization of robot dogs still requires some time. In conclusion,

robot dogs have vast potential for development in the fields of domestic companionship and disaster search and rescue.

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