Pet Care Robot for Playing with Canines

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Abstract This paper observes interactions between a robot and pets, especially canines, and also investigates the feasibility of pet care robot (PCR) as an alternative for human in terms of pet caring based on animal–robot interaction (ARI) with experiments. The paper demonstrates the effectiveness of PCR for playing with pets, which is designed based on ARI, ethology, and user-centered approaches. The experiments were performed to observe the interactions in two conditions: when the dogs meet the robot at the first time and when the dogs already meet the robot for some times. The result summarizes that canines are able to show better interaction performances with robots through repetitive learning with their owners. Furthermore, this result also suggests the feasibility of PCR as an alternative for human pet sitter in terms of the playing function.

1 Introduction

Pets, especially canines, take important roles in modern life. With the level of interest about raising a pet at home, various academic approaches to verify influences of pets on human and society have been reported. A recent study argued that having a pet results in positive effects on physical health status, social participation, and contribution on social capital accumulation [1]. However, there were some observations

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that dogs that are left alone suffer from separation anxiety syndromes [2]. Therefore, there is a need for development of goods and research about caring pets when owners are away from home for their trips.

With a long history of domestic dogs, human–dog interactions have been reported naturally. Beginning with a report by Romanes in 1883 about human–dog interaction, research on cognition of dogs and studies on animal–human interaction (AHI) have been initiated [3]. As a demand for pet sitting increases, a shift from AHI to animal–computer interaction (ACI) or animal–robot interaction (ARI) gains importance in AHI research field. This paradigm shift is connected to realization of PCR, which observes status of the human's partners and looks after them, as an alternative for human pet sitter.

There have been several studies to implement PCR for various kinds of pets. Lakatos measured interactions between dogs and humanoid robot, which performs gestures like pointing, and suggested design method that helps robots be more social to dogs [4]. Another research sought for new interplaying ways by performing experiment, whether dogs can react to the information gained from the TV screen [5]. Kim first defined the term 'ARI', proposed qualifications for PCR, and suggested three functions of PCR: 'Remote Control', 'Playing function', and 'Caring function' [6]. All of these studies aimed to learn how robots can interact effectively and ethically with pets [7].

Based on concepts of ARI and PCR, this paper demonstrates design approaches for playing functions on PCR with experiments and observes differences in dogs' behavior when dogs meet a PCR never seen before and when they meet the PCR after accustomed to it. To implement the robot for playing function in PCR, design methods based on ARI, ethological knowledge, and user-centered design approaches are used for the robot design.

This paper is organized as follows. Section 2 introduces ethological backgrounds and design approaches using concepts of ARI and PCR. Section 3 shows experimental procedures and results. Section 4 provides discussion on the interpretation to the results and future works.

2 Materials and Methods

2.1 Background

Until now, most of research field focused only on human-centered robots. The PCR concept, however, argues that PCR should show different features from characteristics of human-centered robots and suggests considerations on ethology, breed, characteristics, and size of pets. These should be implied in hardware and behavior design. In this section, ethological backgrounds on plays in dogs and design approaches for PCR-based on ARI are introduced.

Play in dogs Nowadays, most ethologists agree that plays include specific distorted behavior patterns that deviate from their original functions and goals [8]. For social mammals that have complex behavior patterns, play offers promotions in behavioral routines, physical, mental exercises, and enforcement on individual relations [9]. Dogs often use playing for building hierarchical relationships [8]. Moreover, plays also have a role as a 'training for the unexpected [10]' finding individual fits for a new challenge under the safety provided by parents or groups [11].

There have been some reports about playing of dogs. Rooney showed that dogs prefer human–dog plays rather than dog-dog plays in object plays because they do not have to compete with human [12]. Furthermore, there was a report about comparing differences in human–dog, social robot–dog, and asocial robot–dog interactions. The report suggested that as more and more the robot become social or manlike, dogs can understand its intention better and be more interactive with it [4].

ARI and PCR In this paper, the robot that plays a role as playing function in PCR is used for showing feasibility of PCR as an alternative for human pet sitters in terms of playing with pets. ARI concept is inspired from Human–Robot Interaction (HRI) concept. It is defined as interactions between animal and robot without any involvement or interference of human. PCR is defined as a robot that interacts with a pet based on its current state for the purpose of pet caring [6].

To be PCR, the robot should satisfy some necessary conditions of ARI. For playing function, required conditions can be summarized as follows:

1. The robot should satisfy ethological playing function.
2. The robot should be familiar with pets in terms of appearances, noises, and scents.
3. The robot should not give fear to the pets. Thus its behavior patterns should be based on 'user-centered' approaches [7].

2.2 Structures

For PCR, the robot should satisfy three necessary conditions that were introduced in above section. To meet those conditions, the robot for the experiment is designed as follow. The robot is designed to provide playing function that is one part of the PCR functions, adopting 'user oriented service providing' method [6]. It means the robot in this experiment is charged only on a playing function, so the robot has no autonomous feedback systems and sensors for vision and auditory. Thus, in this experiment, humans are responsible for observation on current state of pets and giving feedbacks into the robot via watching dogs in separate areas and remote controlling using smartphone.

The spherical robot connected with network through Wi-Fi, which can be controlled via a smartphone application based on android OS, is used for the experiment. To cover noises of motors and attract concerns of dogs, speaker broadcasts voices of the owner. Figure 1 shows the appearance of the robot and Fig. 2 summarizes the overall system.

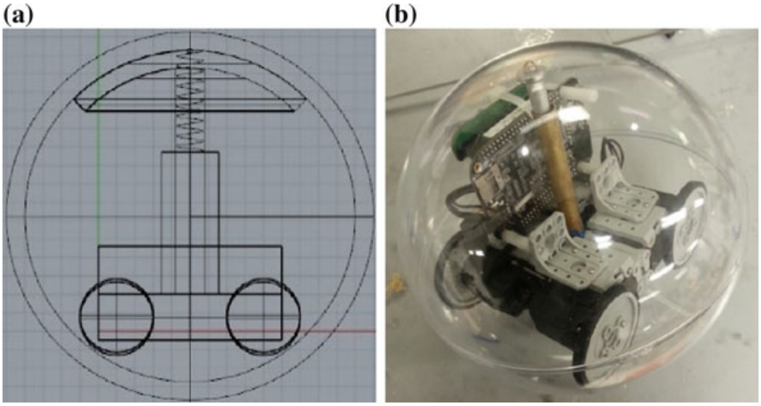
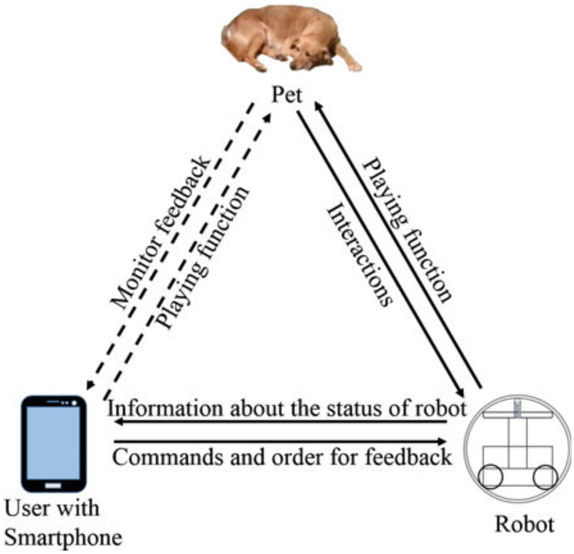


Fig. 1 Design of the robot: **a** Simple structural modeling of the robot. **b** Implementation of the robot without sensors

Fig. 2 Overall system



Hardware The robot is covered by acrylic shell with a diameter of 180.0 mm, and composed of three layers: lower layer, middle layer, and upper layer. Lower layer is responsible for movement, power supply, and keeping balance of the robot. Besides, it contains four DYNAMIXEL AX-18 as motors, a battery, a weight pendulum and plastic frames. Middle layer is composed of an usb hub, a microprocessor (beagle bone black), a Wi-Fi dongle, a sound card, a speaker, and an inertial measurement unit (IMU). Finally, the upper layer takes charge of supporting overall structure with suspension systems and a damper.

Table 1 Short overview of the experimental subject

Index	Breed	Classification	Characteristic index	Sex
1	Golden retriever	Large-sized	5—intimacy, like physical touch	F
2	Golden retriever	Large-sized	3—calm, mild	M
3	Pembroke welsh corge	Medium-sized	3—careful, smart	M
4	Mongrel	Medium-sized	2—timid, cowardly	F
5	Chihuahua	Small-sized	4—outgoing, curiosity	F

Software Movements of the robot are remotely controlled via Wi-Fi networks using an application based on android smartphone. Users can give appropriate commands through the smartphone to manipulate speed, control, automatic navigation, and voice broadcast of the robot. The processor, which receives IMU measurement values, helps the robot to maintain its balance and change its direction to desired one.

2.3 Subjects

For the experiment, subjects are chosen by the following standards:

1. They should have various sizes, breeds, and characteristics.
2. They should have similar experiences in playing.
3. They should have a similar amount of repulsion or familiarity with the objects which are used in object plays.

Thus, five different dogs which are familiar to globelike toys and have the same owner were chosen for subjects of the experiment with an assumption that if they belong to the same owner, they have similar experiences on playing with the same objects. Through the observation before the experiment, personality indexes were marked as 1 for very inactive to 5 for very active. Table 1 summarizes specifications of the subjects.

3 Experiment

The results are marked as average values from grades of three observers. The observers gave grades 0 to 10 for interactions between a dog and the robot. The intention of the experiment is to find answers for the following two questions: *'Can dogs interact with the robot which they never saw before?'* and *'Can dogs interact with the robot after accustomed to it?'*.

3.1 Procedures

Procedure I As a first step, the observers watch the interactions between subjects and the robot which is switched off. This procedure is executed for providing enough time to the subjects for getting accustomed to the experimental environments and smell of the robot.

Procedure II By not providing any information to subjects, the robot gets into close touch with subjects broadcasting voice of the owner through a speaker for 8 min. In this procedure, the observers mark points for each subject how the dogs interact with the robot and record behavior of each dog. The purpose of this step is to know how dogs behave when they meet the robot that they never saw before, but a familiar appearance robot which broadcasts the voice of the owner.

Procedure III In the third procedure, owner introduces the robot to the subjects. To show harmlessness of the robot to the dogs, the owner shows each function of it such as moving or voice broadcasting three times to the subjects. This step lasts for 10 min.

Procedure IV Last procedure lasts for 8 min. Similar to the second procedure, the robot approaches the subjects with broadcasting the owner's voice. From this step, observers give points for the interactions and record differences between the results from this procedure and the results of the Procedure II.

3.2 Results

To answer the suggested questions, the results concentrate on comparing the results when dogs are not accustomed to the robot (Procedures I and II) and accustomed to the robot (Procedures III and IV). For Procedure I, all subjects were not so interested in the robot. They showed typical playing patterns: playing with their tails or chasing each other. By moving and broadcasting the voice, however in Procedure II, subject 1 and 2 showed strong curiosity, and responded to the motions and voices of it. Subject 3 reacted with wary investigation to determine whether the robot is a threat or not. Subject 4 and subject 5 showed strong wariness, and subject 5 failed to interact.

For Procedure III, as the owner showed the robot is harmless, all subjects seemed comfortable, but they displayed a tendency on concentrating to their owner, rather than the robot. In the last procedure, all subjects showed moderate wariness and better performances in interactions with the robot. Subject 3 and 4 reacted more actively in this procedure compared to Procedure II and subject 5 still showed hesitation on making contact with the robot.

Table 2 summarizes the results. The improvement is measured as differences in interaction factor between after learning process (Procedure IV) and before the process (Procedure II) divided by the former factor. The factor of Procedure III have no influence on the improvement, since existence of the owner effects on the interactions.

Table 2 Summary of the results

Index	Procedure II	Procedure III	Procedure IV	Improvement (%)
1	8.67	10.00	9.33	7.07
2	6.33	9.33	8.33	24.01
3	3.67	8.33	6.67	44.98
4	2.33	6.00	5.00	53.40
5	0.33	3.67	1.67	80.24

There are two key points for the experiment. One is verifying the feasibility of PCR as a substitutive pet sitter in the absence of the owner at home, in terms of the playing function based on ARI. The other is observing interaction capabilities of canines with the robot never saw before and differences in interactions with nonacquaintance robot and acquaintance one.

The result shows that canines can interact with a robot never seen before; however, they showed different degrees in interaction performances. Besides, it also revealed that canines outperformed after they learn that the robot is harmless. Thus, the result from the experiments suggests the feasibility of PCR as an alternative for human pet sitters in terms of playing with pets.

4 Conclusion

This paper demonstrated a design method for PCR for playing with canines. The robot was designed based on ARI, ethology, and user-centered approaches with experiments. Through the experiments, it was revealed that PCR can be the alternative of human pet sitter when the owner is absent, in terms of playing function. Besides, the experiments also implicate that by learning that the robot was harmless, canines showed better performances in interaction with it. It infers that PCR can become more effective as an alternative for pet sitter with repetitive learning with their owners. The results also reveal that dogs which have smaller sizes than the robot or careful characteristics cannot adapt to the robot easily. Therefore, the PCR should be designed small enough to give no fear to dogs considering the breeds and characteristics. Since of lack of sensory data, the experiment only tested the playing function of PCR. As a furtherwork, it is needed that testing overall functions of PCR including caring function as well.

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References

1. Wood, L., Giles-Corti, B., Bulsara, M.: The pet connection: pets as a conduit for social capital? Soc. Sci. Med. **61**(6), 1159–1173 (2005)
2. Voith, V.L.: Separation anxiety in dogs. The Compendium on Continuing Education for the Practicing Veterinarian (USA) (1985)
3. Romanes, G.J.: Animal Intelligence, vol. 44. Appleton (1883)
4. Lakatos, G., Janiak, M., Malek, L., Muszynski, R., Konok, V., Tchon, K., Miklósi, Á.: Sensing sociality in dogs: what may make an interactive robot social? Anim. cogn. **17**(2), 387–397 (2014)
5. Hirskyj-Douglas, I.: Is my dog watching tv? In: Animal Computer Interaction. NordiCHI'14 (2014)
6. Kim, J.-H., Choi, S.-H., Kim, D., Kim, J., Cho, M.: Animal-robot interaction for pet caring. In: 2009 IEEE International Symposium on Computational Intelligence in Robotics and Automation (CIRA), pp. 159–164. IEEE (2009)
7. Mancini, C.: Animal-computer interaction: a manifesto. Interactions **18**(4), 69–73 (2011)
8. Miklósi, Á.: Dog Behaviour, Evolution, and Cognition. Oxford University Press (2014)
9. Immelmann, K.: Behavioral Development: the Bielefeld Interdisciplinary Project. CUP Archive (1981)
10. Gould, J.: The quarterly review of biology. Quart. Rev. Biol **51**(2), 211–244 (1976)
11. Burghardt, G.M.: The Genesis of Animal Play: testing the Limits. MIT Press (2005)
12. Scott, J.P., et al.: Animal behaviour. Anim. Behav. (1958)