CONNECTED 2007 INTERNATIONAL CONFERENCE ON DESIGN EDUCATION
9 – 12 JULY 2007, UNIVERSITY OF NEW SOUTH WALES, SYDNEY, AUSTRALIA

Designing Charm: Harnessing the Affective Power of Form in Robotic Development

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ABSTRACT

This paper presents the initial response to the news from Sony that they will cease production of the Aibo robot, which has up to now, provided the player base for the RoboCup League. The design of a new player has all the classic issues of product development but two design considerations stand out: 1. That the new design enhances the scholarly research objectives that have been a driving force behind the RoboCup. 2. That the new design can step up to the challenge of wearing the mantle Aibo has won for itself as an ambassador for Science and Engineering. The design must convey a positive and engaging image through its form as it moves about the field. It is photographed and presented to a far wider audience than simply die-hard robotic fans. Without losing sight of the academic objectives, can the David Beckham factor be captured, technically brilliant and cute.

INTRODUCTION

The news of Sony Corporation's intention to cease production of the Aibo robot was received in early 2006. The now substantial RoboCup community, (Table 1) has had to come to grips with the reality that their existing robot players are not going to be replaced. Like real soccer players the existing robots will succumb to injuries, general wear and tear and have to face the prospect of retirement. For the RoboCup, a new player design presents some definite advantages. The opportunity to rethink the format, specification and generally incorporate many of the technical advances that have arrived since the Aibo was last updated is a major one.

City, Year	Countries	Teams	Jr. Teams	Participants	Visitors
Nagoya, 1997	11	40	-	-	5060
Paris, 1998	16	63	-	237	-
Stockholm, 1999	23	88	3	-	-
Melbourne, 2000	19	116	25	500	-
Seattle, 2001	22	141	25	700	18,300
Fukuoka, 2002	29	188	59	1004	117,300
Padova, 2003	35	135	67	1266	15,000
Lisbon, 2004	37	162	162	1627	-
Osaka, 2005	35	203	163	-	181,540
Bremen, 2006	35	200	240	2500	12,600

Table. 1. Presents the registered attendance numbers for different aspects of the RoboCup illustrating the interest generated over time.

There will of course also be political lobbying and infighting over the direction that the RoboCup League will pursue. The Newcastle Robotics Laboratory at the University of Newcastle, Australia has taken up the challenge and started work on designing a new player for the consideration of the RoboCup league. A player built to be more adaptable, with a greater capacity for upgrading internal components and envisaged as coming in a kit form at present. The project provides a practical platform for the combination of science, technology and design.

The design of the proposed new robot kit aims at improving or at least matching the computational, electrical and mechanical features of Aibo, but must also possess the attractive and alluring characteristics that have captured the public's affections. The kit-style system consists of high quality exchangeable parts, which should make the robot robust and allow for economic maintenance. Other functional design requirements include the ability to reuse significant amounts of the computational concepts and software, which have been developed in the four-legged league so far. Ambiguity, however, surrounds what requirements the new design must meet in order to achieve its aesthetic goals, or indeed how to measure its success in doing so.

I. BACKGROUND

RoboCup has become the largest and most important yearly international event in intelligent robotic multi-agent systems. At its 10th anniversary in 2006 approximately 2500 active participants attended from 35 countries (Table 1). RoboCup comprises a scientific symposium, an industrial robot exhibition, and a set of robot competitions in soccer, rescue, and household tasks (RoboCup, 2006). Associated with RoboCup is the fast growing RoboCup Junior initiative for high school students. The central and largest component of RoboCup is the international robot soccer world cup competition, which consists of several leagues for different types of robots.

Research directions in the different leagues complement each other by emphasizing different aspects of the complex robot soccer task. There are different leagues within RoboCup. Some are simulation-based leagues, while other leagues use central server controls. There is yet another league, which runs fully autonomous wheeled robots on a

8m—12m size field. Research is ongoing into a humanoid league but still has to solve the challenge of robust stabilisation during bipedal walking. So the four-legged league is one amongst many competing for attention. The four-legged competition has run from 1998 to 2006 predominantly as a software-focused league using the Sony Aibo robot (Sony, 2006) as a standard hardware platform. Of the available leagues, the four-legged Aibo league has received a lot of press coverage; this is suspected to be due in part to the Aibo's form, which will be discussed later.

Some of the achievements of RoboCup can be seen as a result of one of its fundamental concepts, which is that RoboCup is a meta evolutionary algorithm to optimize and accelerate research. This becomes particularly apparent in the software focused leagues where teams release their code after the competition to allow other teams to use parts of their code (recombination) or to modify it (mutation) for the next competition (selection). The direct international competition (RoboCup) evaluates the quality and effectiveness of research outcomes by determining what works better in direct comparison. The fundamental concept is survival of the fittest within the environment of RoboCup. In contrast to traditional academic and industrial research where the opinion of experts, publication outcomes, and economic values can determine the value of research results over a longer period of time RoboCup aims at obtaining high quality results very quickly.

The Sony four-legged league is often regarded as the most popular league of RoboCup. Through development of a robust and fast quadruped walk and techniques for precise localisation of the autonomous robots, exciting soccer play has been achieved in recent years. The quickly developing capabilities of the robots and the high level of play have been astonishing for both researchers and general audiences every year. Some of the top teams of the four-legged league in 2006 demonstrated effective goalie-behaviour, cooperative and adaptive team positioning, active perception, and occasionally even deliberate passing between field players. The four-legged league also counts as one of the core motivators for many thousands of young students from over 22 countries who have joined the rapidly growing international RoboCup Junior initiative.

Since Sony Corporation announced the later model Aibo robot illustrated in Figure 3 was to go out of production. The present proposal presents a prototype for a new kit based on a hardware system which addresses two general challenges:
(I) A new standard platform for the four-legged league should be designed to support the evolving of all aspects of the hardware design, in conjunction with software developments, until realistic quadruped robot soccer can be achieved.
(II) Aibo was an extremely popular and sophisticated robot (Fujita and Kageyama, 1997; Fujita and Kitano, 1998). Its friendly and aesthetic design contributed significantly to the success and high popularity of the four-legged league and associated projects. Therefore a new robot for the four-legged league should have a similarly attractive visual design.

Fig. 3. Images of the Aibo robots, which have been used in the RoboCup League. An earlier model ERS-210a (left) and the most recent Aibo model ERS-7W (right).

The kit style robot concept proposed in the present paper presents a new challenge for the technical committee of the league, which would have to define the details of the standard platform and possibly incremental hardware upgrades for each year. The project in its present state of development is illustrated in Figure 4. Stepping up to a new hardware platform provides the opportunity for significant advancements of skill standard and research achieved so far in the four-legged league.

Fig. 4. This image shows an assembled 'new player' platform at its present stage of development. It is sitting behind an official four-legged league ball.

II. Character Development: A Visual Perspective

The visual design of Aibo has a 'cute' element, which has been part of the success of the four-legged league competition to date that should be captured by the new proposal as well. In Figure 1 a preliminary concept drawing is provided which displays the general form of a terrier. This type of dog has exhibited a wide and enduring public appeal in the classic Tin Tin cartoon series by Georges R´emi (Herg´e). The terrier form was also considered a suitable dog type to focus on because the new internal componentry of the legs bulked out the lower section of each leg. The terrier was one of the few dog forms where the bulky leg shape did not interfere with the 'dog' semantic. The terrier concept is an

initial response and will be the subject of future study to determine the best robotic form to promote the RoboCup's interests.

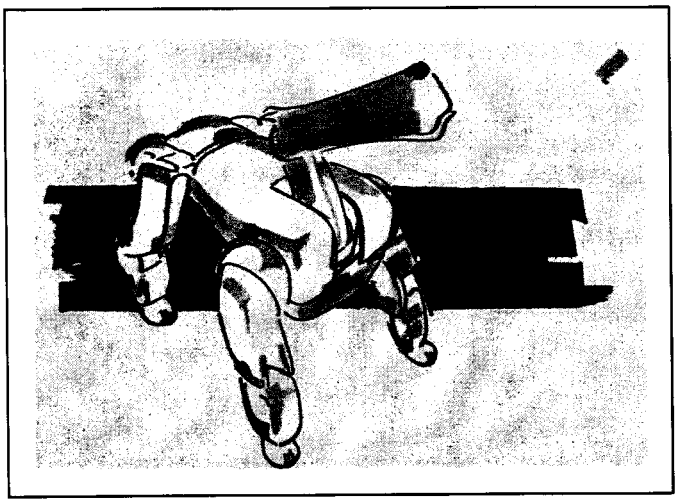

Fig. 1. One of the initial concepts drawings of the external form of the 'new player'. It conforms to the proposed internal components and identification with the form of a terrier. This image was part of a PowerPoint presentation delivered at the Bremen RoboCup (Chalup, 2006).

Specific aspects of the proposed design, effected by pursuing this aesthetic direction, are the leg placement and the head configuration. One characteristic feature for a terrier is that the distance between the hip joints is much closer than the distance between the shoulder joints. While presenting visual clues to the terrier dog type (Fig. 1), over-exaggeration of this feature may lead to an aggressive appearance. Balancing of the visual details will be part of the continuing proposal development. Of great importance is the design of the visual details of the head. The head is a key element in determining the character of the robot and how the semantic messages are received by the audience. Some example drawings of possible head designs are displayed in Figure 2.

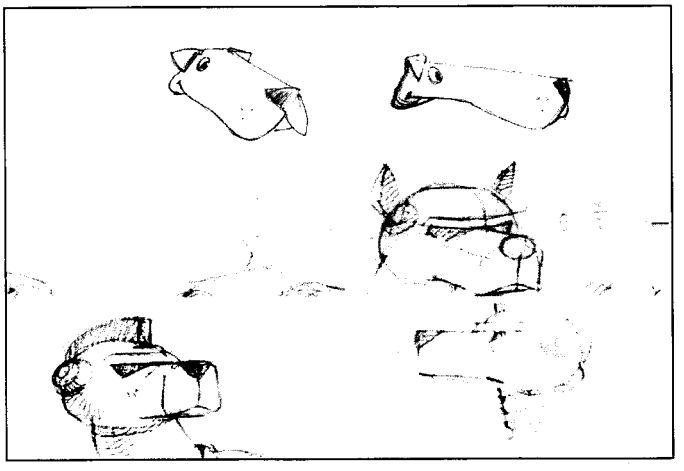

Fig. 2. Head design studies ranging from the comical to the aggressive. These studies will be better informed with the implementation of a survey as proposed in section 3. These images were presented for discussion at the Bremen RoboCup (Chalup, 2006).

The mechanical and electrical design of the robot does not impose severe constraints on determining the shape of the head. Therefore a large variety of different designs in this area are possible. The legs on the other hand have severe restrictions due to the componentry contained within. The body has some flexibility as long as space for the major components is factored in. At this stage, a final decision for a particular head design for the prototype has not yet been made. Reference to the uncanny valley principle (MacDorman, 2005a) will also have to be considered.

III. Assessing the Affective Power of Form

As stated earlier, one of the design issues to be addressed concerns the creation of a character for the robot that will facilitate a positive emotional and semantic connection. Factors such as the robot's form, surface aesthetics, movement and mannerisms will all play a part in convincing both the RoboCup league members and other followers of their activities that the robot is lovable and entertaining.

One concern that surfaces in such a process is the risk of falling into the uncanny valley (Mori, 1970). The uncanny valley is a hypothesis that describes the sudden negative emotional response evoked within a person who encounters a robot who appears remarkably life-like, yet is still notably artificial. The commercial failure of productions such as 'Final Fantasy: The Spirits Within', a science fiction film by Hironobu Sakaguchi in 2001 which boasted to be the first animated feature to deliberately portray photorealistic CGI humans, is often attributed to this phenomenon. Despite having the capacity to produce similar material, other animation studios such as Pixar/Disney and Dreamworks have deliberately avoided producing photorealistic human characters in their feature films, opting instead for more caricatured or comic-like equivalents. MacDorman (2005b) suggests that the eerie and uncomfortable reaction associated with the uncanny valley may well be because the likeness presented harkens to that of a moving corpse and we are subsequently reminded of our mortality. In any case, the uncanny valley is a reference to humanoid forms, and as this design concerns that of a canine form, it is anticipated that the effect of such a phenomenon would be minimal.

The question still remains, however, as to what particular canine forms evoke an appropriate semantic and which do not. As was just implied in our discussion of the uncanny valley, strong negative connections can be activated. Just as a realistic android might remind a person of a zombie from a horror film, a robot dog resembling an angry Doberman might also elicit a threatened or fearful response. It could be argued that almost every well-known canine breed has some sort of associated stereotype or semantic value. A Greyhound might have connotations of speed, a Corgi of opulence, a German Shepherd of security and a Labrador of guidance or intelligence. In order to establish an initial direction as to

what canine forms will be most appropriate, data related to their general perception and preference will be needed (see figure 5). A large register of RoboCup members exists that could be used as a basis to evaluate a variety of proposals, which could be compared to that of the general public. This has two advantages, one is helping the development of a new prototype, and the second is to quantify if there are discernable differences to the responses to the form within identifiable groups.

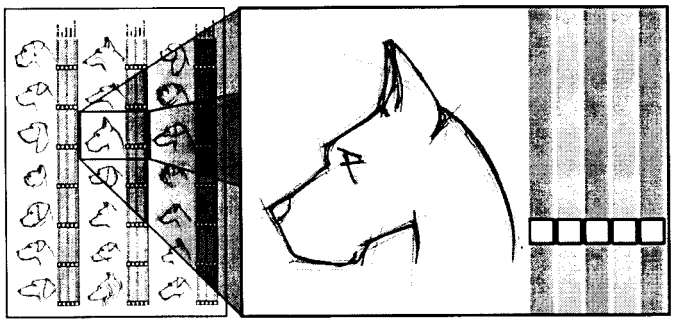

Fig. 5. A draft survey designed to gather data on preferences for various canine profiles.

To progress the development of an effective research approach, a draft survey has been put forward to generate discussion. Another design research method that is being considered is perceptive sorting, which was incidentally used by Forlizzi (2003) in a study that incorporated an Aibo and may have useful connections to this investigation. However an adaptation of, Russell's (1980) 'circumplex model of affect' demonstrated by Reijneveld (2003) will also be considered for incorporation in the final approach.

IV. Discussion

A successful design solution for the RoboCup league will move physically. It will provide a platform for uniting science, technology and design. Furthering research into physical robotic controlled movement while providing opportunities to enhance and change the internal technology as new developments and directions occur.

The design will also move people emotionally. Delivering a positive, powerful, non-verbal message through its physical presentation for the fields of science and engineering. It is postulated that if the design can harness the 'cute' factor, it will enhance the transmission of the message to an even wider audience. How to do this will become a major part of this project. The confluence of a number of the factors discussed in this report make this project an ideal opportunity to implement and test the affective power of form. In designing a form that displays affective power and conveys a positive message to the RoboCup members and the general public.

ACKNOWLEDGMENT

This paper has drawn upon edited and expanded material from an earlier document: S. K. Chalup, M. Dickinson, R. H. Middleton, M. J. Quinlan, P. Turner: "Proposal of a Kit-Style Robot as New Standard Platform for the Four-Legged League". Internal report, Newcastle Robotics Lab, www.robots.newcastle.edu.au, 2006.

REFERENCES

Chalup, S. K., Dickinson, M., Middleton, R.H., Quinlan, M.J., Turner, P. 2006. Development of a new standard platform for the four-legged league of robocup, Presentation at the Dagstuhl Seminar N°06251,19.06.-23.06.06: *Multi-Robot Systems: Perception, Behaviors, Learning, and Action*, Available at: http://kathrin.dagstuhl.de/06251/Materials2/

Forlizzi, J., Gemperle, F., DiSalvo, C. 2003. Perceptive sorting: A method for understanding responses to products. In: *DPPI'03 Conference Proceedings*, June 23-26, Pittsburgh, Pennsylvania, USA, 103-108

Fujita, M., Kageyama, K. 1997. *An Open Architecture For Robot Entertainment.* ACM Press, 435-442

Fujita, M., Kitano, H. 1998. Development of an autonomous quadruped robot for robot entertainment. *Autonomous Robots*, Vol. 5, No.1, 7–18

MacDorman, K.F. 2005. Androids as an experimental apparatus: Why is there an uncanny valley and can we exploit it? In: *CogSci-2005 Workshop: Toward Social Mechanisms of Android Science*, 106–118

MacDorman, K.F. 2005. Mortality salience and the uncanny valley. *Humanoid Robots, 5th IEEE-RAS International Conference*, Pub. Date: Dec. 5, 399- 405

Mori, M. 1970. *Bukimi no tani.* Translated by Karl F. MacDorman and Takashi Minato (The uncanny valley). Energy, 7(4) (1970) 33-35

Reijneveld, K., de Looze, M., Krause, F. 2003. Measuring the emotions elicited by office chairs, In: *DPPI'03 conference proceedings*, June 23-26, Pittsburgh, Pennsylvania, USA, 6-10

RoboCup. 2006. *RoboCup 2006 Website* [Online] RoboCup Federation, Available at: www.robocup2006.org

Russell, J.A.: A circumplex model of affect. Journal of personality and social psychology, 39 (1980) 1161-1178

Sony. 2006. *Sony's Global Home Page* [Online] Sony Corporation, Available at: www.sony.net.