
17th International Conference on
ELECTRICAL
DRIVES
and
POWER
ELECTRONICS
EDPE'11
(The 5th Joint Slovak-Croatian Conference)
PROGRAMME
28 - 30 September 2011, The High Tatras, Slovakia

17th Int. Conference on
Electrical Drives
and
Power Electronics
The High Tatras, Slovakia
28–30 September, 2011

Robot with Dog Type Behavior

Bence Kovács [1)], Géza Szayer [1)], Ferenc Tajti [1)], Péter Korondi [1)], István Nagy [2)]
[1)] Department of Mechatronics, Optics and Applied Informatics, Budapest University of Technology and Economics, Budapest, Hungary, e-mail: korondi@mogi.bme.hu
[2)] Department of Automation and Applied Informatics, Budapest University of Technology and Economics, Budapest, Hungary, e-mail: nagy@get.bme.hu

Abstract— **The aim of this paper is to place the relation of human and robots on a new, ethologically inspired base. So far, when designing robot interaction mainly ergonomic and psychological aspects were taken into consideration to form the human-system relationship. Since robots perform an inferior role to their human user, we consider that a more successful human-robot relationship could be set up if the communication and interaction between them were based on ethological aspects. The aim of this paper is to work out this paradigm shift, considering philosophical, epistemological, mathematical and implementation aspects. This paper takes the abstract ethological model of the 20,000 year old human-dog relationship as the base of the human- robot interaction.**

Keywords—Intelligent drive, robotics, system integration, ethology

I. INTRODUCTION

In recent years there has been an increased interest in the development of Human-Robot Interaction (HRI). Researchers have assumed that HRI could be enhanced if these intelligent systems were able to express some pattern of sociocognitive and socioemotional behaviour [1]. Such approach needed an interaction among various scientific disciplines including psychology, cognitive science, social sciences, artificial intelligence, computer science and robotics. The main goal has been to find ways in which humans can interact with these systems in a “natural” way. Recently HRI has become very user oriented, that is, the performance of the robot is evaluated from the user’s perspective. This view also reinforces arguments that robots do not only need to display certain emotional and cognitive skills but also showing features of individuality. Generally however, most socially interactive robots are not able to support long-term interaction with humans, and the interest shown toward them wears out rapidly. The "sensitivity communication" robot Ifbot [5,6,7] was developed to investigate human-robot interaction. Ifbot is able to recognize people's emotion based on the tone of their voice, is able to represent emotional states and is able to express six basic emotions on its face. The facial expressions are mapped to an emotional space which is represented by a neural network. The third layer of the special five-layer perceptron was used to extract characteristics of facial expressions in order to identify emotions. This solution results in a 3D emotional model where the trajectory in the emotional space of a facial expression can be mapped to a defined emotion. The facial expressions are learned by the neural network and a smoothing method is used to achieve seamless facial control.

The huggable robot Probo [8, 9, 10] was created for therapeutic purposes, it functions as a robotic user interface between an operator and a child. Probo's interaction is carried out by use of cameras, touch sensors, microphones on the input side and speakers and facial expressions on the output side. In [8] the authors write about the influence of the input stimuli on the attention- and emotion system. A three level behavior-based framework [11] (reactive, routine and reflective level) is presented in [12] of which Probo implements the first two levels (the third level is regarded as future work). Using the three levels Probo will be able to have short- and medium-term emotional responses. The emotional space is set up by two parameters: arousal and valence. The emotion interpretation method results in a specific emotion and a corresponding intensity.

The "iCat" user-interface robot [13, 14, 15, 16] uses the approach of applying animation principles to robotics to create believable behavior in order to increase its life-likeness. iCat is a desktop user-interface robot with mechanically rendered facial expressions. The animated behavior of iCat robot is divided into two parts: *mode animation* (medium-term) and action animation (short-term). To define the behavior of mode animation a probabilistic automaton was used. In c authors argue that using probabilities for the mode behavior results in more authentic behavior. The main strength of iCat is the highly elaborated emotion interpretation by means of facial expression based on animation techniques.

In the frame of the EmotiRob project [17] the companion robot called EmI was designed for therapeutic purposes. Inputs are video and audio signals which allow EmI to detect the emotional state of the human partner. Each experienced action or word is associated with a vector of primary emotions. This causes the emotions of the robot to change dynamically. The emotional experience is generated based on the emotional state of the robot and its human partner. The designers of EmI propose a solution for the emotion transitions by defining a tree of emotion transitions.

The robot Kismet [18] was developed to explore issues in building social intelligent autonomous robots. Kismet has a vision system, microphones, a speech synthesizer, a two degree of freedom neck, and facial features which enable it to display a wide variety of recognizable expressions. Kismet's designers integrate in their emotional modeling work inspirations and theories from infant social development, psychology, ethology, and evolution enabling the robot to enter into natural social interaction with a human. The emotion system defines "emotions" and "drives" where drives operate on a slower time scale than emotions, drives contribute to the "mood" (medium-term) of the robot. A detailed description about Kismet's elaborated emotion system -- how inputs stimulate it, how the emotional space is set up, and how emotion arbitration is processed -- can be found in [18].

The autonomous robot Aibo [19] was designed for entertainment purposes. The pet-like robot can move its four legs, its neck and its tail, has LEDs on its face and can play sound patterns while its input stimuli come from vision and sound processing. To maximize lifelike appearance designers intended to maximize the complexity of responses and behaviors of the robot.

The emotional basis is split into drives and six basic emotions. Aibo's behavioral system was inspired by the study of canine behavior. The designers distinguish between *reflexive* (short-term) and *deliberate* (medium-term) behaviors. To increase the complexity of behaviors a stochastic state-machine is implemented to enable the addition of randomness in action generation and to realize nonrepeated behavior exhibition. The detailed description of the behavioral and emotional model of Aibo can be found in [19].

This paper is organized as follows. Section II presents our ethology inspired concept. Section III gives an overview on the related technologies Section IV deals with the ethological background of our approach. Section V describes our robot. Finally, Section VI concludes the paper and sketches possible future work

II. CONCEPT

Layout The design of socially interactive robots has faced many challenges. Despite major advances there are still many obstacles to be solved in order to achieve a natural-like interaction between robots and humans.

One of them is the "uncanny valley" effect. Mori [2] assumed that the increasing similarity of robots to humans will actually increase the chances that humans refuse interaction (will be frightened from) very human-like agents. Although many take this effect for granted only little actual research was devoted to this issue. Many argue that once an agent passes certain level of similarity, as it is the case in the most recent visual characters in computer graphics, people will treat them just as people [3]. However, in the case of 3D robots, the answer is presently less clear, as up to date technology is very crude in reproducing natural-like behaviour, emotions and verbal interaction. Thus for robotics the uncanny valley effect will present a continuing challenge in the near future.

During the evolution of humans several ways of human to human communication have exfoliated, along with several communication channels. When we communicate to a machine we can feel something strange. Sometimes a robot can generate grammatically excellent sentence but something is missing. Even if we use a machine to transfer the thoughts of another person only for example using a computer for chatting we lose a great amount of information. This is the reason why we use smileys. Nowadays the need for communication channels in operation beyond the words between humans and artificial tools is growing and there are several researches which try to humanize the intelligent systems.

Our approach is different (see Fig. 1). The main contribution of this paper is to put the human and IS interaction to a new, ethologically inspired base. According to this new paradigm the IS should not be molded to mimic the human being, and form human-to-human like (intra-species) communication, but to follow the existing biological examples and form inter-species interaction. In this paper we utilize the 20,000 year old human-dog relationship as a model for our new paradigm, that is putting the human-IS interaction in a hetero-specific (between species) interaction.

We provided a mathematical model for modelling human-dog attachment [36] and implement this model on a robot which is moving in the intelligent space.

We adapted Fuzzy Automaton and Hybrid Fuzzy Rule Interpolation methods in new ethologically inspired fuzzy model structures for model identification and validation purposes [37,38].

We produced a mathematical model for mechano-visual signalling expressing the inner state of the robot ("antenna"), and this capacity will be integrated with the attachment model.

We designed a simple robot that shows analogous behaviours to a pet animal by moving in space and signalling its inner state by the mechano-visual signalling system. This robot will be used to validate our mathematical model in real time and space by interacting with humans.

We designed an abstract etho-model based on attachment behaviour which was implemented in intelligent personal computational device like smart telephone or PDA [39].

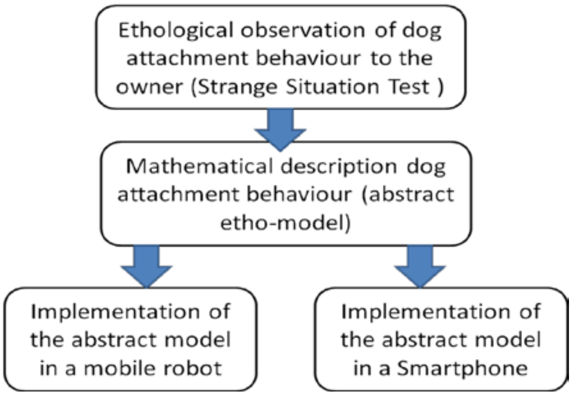

Figure 1. Our basic concept

III. OVERVIEW OF RELATED TECHNOLOGIES

A. Human-Computer and Human-Robot interaction (HC/RI): Present state, goals and trends

In recent years there has been an increased interest in the development of HC/RI. Researchers have assumed that HC/RI could be enhanced if these intelligent systems were able to express some pattern of sociocognitive and socioemotional behaviour (e.g. [1]). Such approach needed an interaction among various scientific disciplines including psychology, cognitive science, social sciences, artificial intelligence, computer science and robotics. The main goal has been to find ways in which humans can interact with these systems in a “natural” way. In the case of HCI this approach lead to the development of a field called “affective computing” pursuing the goal to endow the computer with sociocognitive and emotional abilities that capitalize on the user’s psychological desire to execute work in social context (in collaboration with “others”).

Recently HRI has become very user oriented, that is, the performance of the robot is evaluated from the user’s perspective. This view also reinforces arguments that robots do not only need to display certain emotional and cognitive skills but also showing features of individuality. Generally however, most socially interactive robots are not able to support long-term interaction with humans, and the interest shown toward them wears out rapidly.

A. IR modelling: Current issues

While there is a need for a mathematical model of the system, the complexity of the applied solution must fit the complexity of the problem. In case of neural networks it concerns the number of the neurons and connections, in case of fuzzy logic system, there is a minimal value of the number of the fuzzy sets and fuzzy rules. Moreover in case of classical compositional fuzzy reasoning methods ([20,21,22]), or in the Takagi–Sugeno type fuzzy reasoning ([23,24]), because of the demanded completeness of the fuzzy rule base, in many cases, much more fuzzy rules have to be implemented, than the number of the rules required by the problem complexity demand.

B. Intelligent space

The Intelligent Space (iSpace) is an intelligent environment which provides both information and physical supports to humans and robots in order to enhance their performances [25]. In order to observe the dynamic environment, many intelligent devices, which are called Distributed Intelligent Network Devices, are installed in the room.

The DIND is a fundamental element of the iSpace [26]. It consists of three basic components including sensors, processors and network devices. By communicating with each DIND, iSpace can perceive and understand events in the whole space. In addition to observation, the iSpace actuates intelligent agents such as mobile robots, computer devices and digital equipment.

C. Middleware technologies for robotics

The Japanese Ministry of Economy, Trade and Industry (METI) in collaboration with the Japan Robot Association (JARA) and National Institute of Advanced Industrial Science and Technology (AIST) started a 3 year-national project “Consolidation of Software Infrastructure for Robot Development” in 2002. With the intention of implementing robot systems to meet diversified users' needs, this project has pursued R&D of technologies to make up robots and their functional parts in modular structure at the software level, and to allow system designers or integrators building versatile robots or systems with relative ease by simply combining selected modular parts. The robot technology middleware having been developed as infrastructure software for implementing the proposed robot architecture, named "OpenRTM-aist" (Open Robot Technology Middleware).

To manage a rapidly growing need for sensor communication in robotic applications several suitable architectures, named middleware’s, is being developed for easy system integration. Unfortunately, most of these middleware technologies are developed independently of each other and are often dedicated for specific user applications [27]. RT-Middleware is the only middleware solution that is under standardization and also this solution has proved to be industry ready and used by many industrial partners Toshiba (different system components), Honda (ASIMO humanoid robot), AIST (OpenHRP humanoid robot), etc.) and also many research institutes.

IV. ETHOLOGICAL BACKGROUND

A. Attachment

The concept of attachment defines a specific social relationship between two individuals of a species. The idea was introduced by Bowlby [28] for describing mother-infant relationship but later ethologists have extended this concept to other non-human animals [29]. Importantly, Ainsworth et al [30] developed a method that allows for measuring attachment behaviour objectively (“Strange Situation Test - SST”). In recent years Topál et al [31] have used the SST to show attachment behaviour in dog-human dyads. In previous years we tested approximately 200 dogs, and the results show that the attachment behaviour in dogs is species specific, there is a consistent pattern among individuals which is stable over a period of 5-6 month, and emerges around the 4 months of age (e.g. [32]). Attachment behaviour seem to be breed-independent however, the distribution of dogs with a particular type of attachment may vary across breeds. This suggests the contribution of a genetic component, which is important because people may differ in their preference for animals with certain type of attachment. Attachment can develop very rapidly, after a short interaction with humans [33]. This version of the SST consists of a series of short observations in which the dog’s behaviour is observed in the presence and absence of the owner and the stranger. The spatial pattern of behaviour (closeness to owner/stranger), the behaviour toward the owner/stranger at re-union, and in their absence are observed and described in a quantitative way. (see Fig. 1 for illustration of SST)

Based on this test researchers have identified three main factors that influence the displayed behaviour. Based on genetic endowment and earlier experience each individual shows a specific behaviour pattern that can be described by a characteristic value which will determine how it reacts to these factors. These factors are the following:

- The novelty value of the actual location;
- the attraction to or fear of strangers;
- the attachment to the owner.

Unfortunately, so far there are no experimental data on the variability of dogs with respect to these variables, and need to be determined experimentally. Experimental work has established a set of criterions the fulfilment of which indicates the presence of attachment (Rajecky et al [34]:

(a) an ability to discriminate and respond differentially to the object of attachment (secure-base effect),
(b) preference for the attachment figure (proximity and contact seeking), and
(c) response to separation from and reunion with the attachment figure that is distinct from responses to others including special communicative relationship („greeting").

Recent ethological research has brought dog into the foreground as the living prototype of social robots if we define robots as agents that are built to extend human capacities. The domestication of dogs began around 20.000 years ago, and since then dogs have been utilized by humans for different purposes that all needed some kind of mutual social understanding [32]. Ethologically inspired research shows that during the long-term human-dog relationship dogs have evolved behavioral skills which have increased the chances to survive in the anthropogenic environment [33]. Regarding communication, for example, dogs have evolved skills that enrich their capacities to communicate with humans in complex social situations [34].

Humans prefer to set up social relationships with agents that they cooperate with. Furthermore, humans are able and prefer to perceive certain human-like mental capacities, such as emotions, in other agents to ease the interaction with them. Dogs use a variety of visual (e.g. tail movement) and acoustic cues (e.g. frequency and tonality of barking) to express their emotional states, and humans seem to be able to recognize dogs' basic emotions without much specific experience [35]. These behavioral cues may be partly redundant making the emotional behavior unambiguous and simplifying the recognition of the emotion.

It is important to emphasize that, on the engineering side, we do not want to provide an emotional model of the dog. We consider the analogy as important when modeling the emotional space of an artificial agent.

We design human-robot interaction and are interested in emotions that humans assume and recognize interacting with another species for which the dog may be a key example.

V. IMPLEMENTATION OF THE ABSTRACT MODEL IN A MOBILE ROBOT

A. Implementation of the Strange Situation Test

The proposed experiential set up can be seen in Fig, 2 (a functional copy of the real SST). Adapting the concept of the intelligent space, the position of owner, stranger, robot and toy is tracked by a camera system. Based on image processing and expert system components the intelligent space provides the positional and action information to the virtual dog SST emotional model. The abstract emotional model calculates the observable reactions and a new state value for the model. The observable reactions, including the new positional information

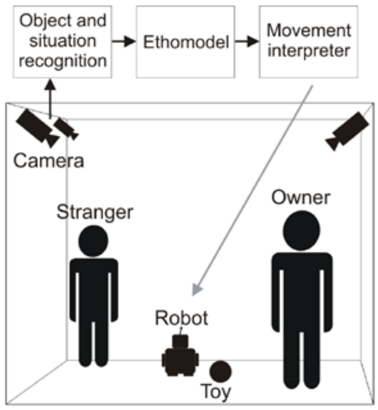

Figure 2. The robot and its ethological model.

then is sent back to the robot through wireless communication, applying the communication subsystem of the intelligent space. For easier visual human role recognition, the "owner" and "stranger" will be also distinguished by special markers for simplifying the task of the visual and image processing subsystem.

B. Robot basement and basic elements

The drive system of the designed robot is a special wheel based drive (see in Fig 3). There are several arguments against legs:

- Moving on legs need much more power, than rolling on wheels.
- A mechanic of a leg and controlling its joints for smooth moving is too difficult and expensive. That is not the main issue of an ethological based robot.

The most of the overland animals can move in 3DoF: turning and moving in one direction in the same time. The ordinary drive systems (steered wheels, differential drive) can not perform this. These systems called non-holonomic mechanical systems. These can reach every coordinate in the 3DoF coordinate system, but can move in less direction at the same time. So it is necessary to build a special wheel based drive system that has the 3DoF at every time. These systems called holonomic mechanical systems. The designed system based on holonomic wheels (or omniwheels). (see in Fig 4.). Maximal speed is 2 m/s (7,2 km/h). The robot head (shown in Fig. 5) is moved by a 3DoF neck servo (see in Fig. 6) The gripper has a very important role when we play with the robot. The robot can fetch a ball with it. (see in Fig 7).

C. Nonverbal communication by mechanical signals ("antennae")

Animal use various species specific behaviour patterns for communication. The utilisation of such behaviour pattern in the communicative behaviour depends on evolutionary factors. Importantly, although many animal species have a tail, its function can be very different (e.g. squirrel – balance, monkey – climbing) or there is no tail (human). In the case of dogs/cats (predators) tail has a communicative function. The tail is a very special tool for communicate information in the visual

Figure 3. The robot basement

Figure 4 The robot omniwheels

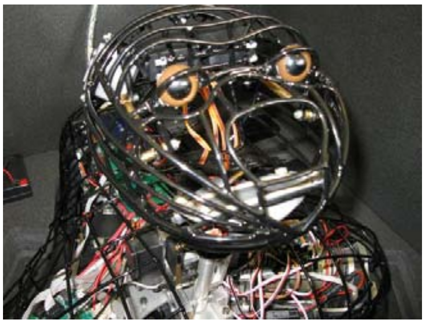

Figure 5 The robot head

Figure 6 Structure of the neck

Figure 7 The gripper

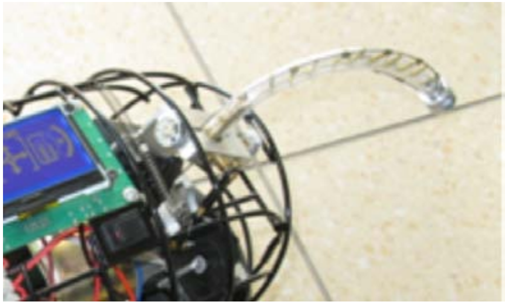

Figure 8 Tail of the robot.

mode. For example, recent research has shown how lizards use their tail for communicating when the background visual noise is different [35]. Dogs are very different from humans because the former utilize the tail as a means of communicative signals. Here we aim to show that a mechanical structure (that does not necessarily mimic a tail directly) and does not resemble human communicative behaviour pattern, can, nevertheless, elicit communicative interaction in humans. Although in the primer experiment the inner state ("attachment") of the subject is expressed to some extent by its behaviour (distance from owner/stranger etc.) during the SST, in reality dog-human interaction is rich in communicative exchanges. Thus we hypothesise that the addition of such a communicative devise could facilitate human-robot interaction. If the tail-like part (or "antennae") gains a functional value, one might think how to transform this rule structure into other communicative channels such as audition or other visual effects. Adding such communicative skills to the robots, which show attachment behaviour, will certainly enhance their attractiveness toward humans.

VI. Conclusion

The goal of this paper was to suggest a behaviour-based structure built from Fuzzy Rule Interpolation (FRI) models and FRI automaton for handling Human-Robot Interaction (HRI) placed on ethological model basis. The suggested structure is simple and could be implemented to be quick enough to fit the requirements of direct real-time HRI applications. It is an easily built and simply adaptable structure for many application areas. The implementation of FRI reasoning methods in HRI applications simplifies the task of fuzzy rule base creation. The FRI rule base is not needed to be complete, so it is enough to concentrate on the main control actions, or even the rules can be added simply piece by piece. The robot can cooperate with dogs (See in Fig. 10.)

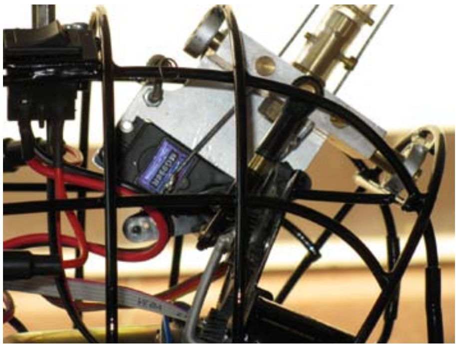

Figure 9 Servo motors of the tail

Acknowledgements

The authors wish to thank the support to the Hungarian Research Fund (OTKA K72338) and the Control Research Group of HAS. This work is connected to the scientific program of the "Development of quality-oriented and harmonized R+D+I strategy and functional model at BME" project. This project is supported by the New Széchenyi Plan (Project ID: TÁMOP-4.2.1/B-09/1/KMR-2010-0002).

Figure 10 The robot and its ethological model.

REFERENCES

[1] K. Dautenhahn, “Methodology and themes of human-robot interaction: A growing research field” Int. J. of Advanced Robotic Systems, 4, 2007, pp.103- 108.

[2] Masahiro Mori, The Uncanny Valley, Energy, 7 (4), 1970, pp.33-35.

[3] M. Potal Overcoming the uncanny valley. IEEE Compuer Graphics and Applications, 4, 2008, pp.11-17

[4] Á. Miklósi, Dog behaviour, evolution and cognition. Oxford University Press, 2007.

[5] M. Kanoh, S. Kato, and H. Itoh, “Analyzing emotional space in sensitivity communication robot ’Ifbot’,” in *PRICAI 2004: Trends in Artificial Intelligence*, 2004, pp. 991–992.

[6] M. Kanoh, S. Iwata, S. Kato, and H. Itoh, “Emotive facial expressions of sensitivity communication robot ’Ifbot’,” *KANSEI Engineering International*, vol. 5, no. 3, pp. 35–42, 2005.

[7] M. Kanoh, S. Kato, and H. Itoh, “Facial expressions using emotional space in sensitivity communication robot ’Ifbot’,” in *2004 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Sendai, Japan, 2004, pp. 1586–1591.

[8] K. Goris, J. Saldien, B. Vanderborght, D. Lefeber, “Probo, an intelligent huggable robot for HRI studies with children,” in *Human- Robot Interaction*,. INTECH, 2010, pp. 33–42.

[9] K. Goris, J. Saldien, and D. Lefeber, “Probo, a testbed for human robot interaction,” ACM/IEEE International Conference on Human *Robot Interaction*, New York, NY, USA, 2009, pp. 253–254.

[10] J. Saldien, K. Goris, S. Yilmazyildiz, W. Verhelst, and D. Lefeber, “On the design of the huggable robot Probo,” *Journal of Physical Agents*, vol. 2, no. 2, pp. 3–12, 2008.

[11] A. Ortony, D. Norman, and W. Revelle, “7 affect and proto-affect in effective functioning,” in *Who needs emotions?: The Brain Meets the Robot*, 2005.

[12] J. Saldien, K. Goris, S. Yilmazyildiz, W. Verhelst, and D. Lefeber, “On the design of the huggable robot Probo,” *Journal of Physical Agents*, vol. 2, no. 2, pp. 3–12, 2008.

[13] A. van Breemen and Y. Xue, “Advanced animation engine for User-Interface robots,” in *Intelligent Robots and Systems, International Conference on*, Beijing, China, 2006, pp. 1824–1830.

[14] A van Breemen, “Bringing robots to life: Applying principles of animation to robots,” in *CHI 2004 Workshop on Shaping Human Robot Interaction*, Vienna, Austria, 2004.

[15] A van Breemen, “Animation engine for believable interactive user-interface robots,” in *Intelligent Robots and Systems, 2004. (IROS 2004). Proceedings. 2004 IEEE/RSJ International Conference on*, Sendai, Japan, 2004, pp. 2873–2878 vol.3.

[16] M. Saerbeck and A. van Breemen, “Design guidelines and tools for creating believable motion for personal robots,” in *Robot and Human interactive Communication, 2007. RO-MAN 2007. The 16th IEEE International Symposium on*, 2007, pp. 386–391.

[17] S. Saint-Aime, B. Le-Pevedic, D. Duhaut, and T. Shibata, “EmotiRob: companion robot project,” in *Robot and Human interactive Communication, 2007. RO-MAN 2007. The 16th IEEE International Symposium on*, 2007, pp. 919–924.

[18] C. Breazeal, “Emotion and sociable humanoid robots,” *International Journal of Human-Computer Studies*, vol. 59, no. 1-2, pp. 119–155, Jul. 2003.

[19] R. C. Arkin, M. Fujita, T. Takagi, and R. Hasegawa, “An ethological and emotional basis for human-robot interaction,” *Robotics and Autonomous Systems*, vol. 42, no. 3-4, pp. 191–201, 2003.

[20] L. A. Zadeh (1973). *Outline of a new approach to the analysis of complex systems and decision processes.* IEEE Trans. on SMC, (3), 28-44.

[21] E. H. Mamdani and S. Assilian (1975). *An experiment in linguistic synthesis with a fuzzy logic controller.* Int. J. of Man Machine Studies, (7), 1-13.

[22] P. M. Larsen 1980. Industrial application of fuzzy logic control. Int. J. of Man Machine Studies, (12) 4, 3-10.

[23] M. Sugeno (1985). *An introductory survey of fuzzy control.* Information Science, (36), 59-83.

[24] T. Takagi and M. Sugeno (1985). Fuzzy identification of systems and its applications to modeling and control. IEEE Trans. on SMC, (15), 116

[25] Korondi, P., Hideki Hashimoto, ”INTELLIGENT SPACE, AS AN INTEGRATED INTELLIGENT SYSTEM”, Keynote paper of International Conference on Electrical Drives and Power Electronics, Proceedings pp. 24-31. 2003.

[26] Toshima, Y; N. Ando and H. Hashimoto, "Information Display System using Active Projector in Intelligent Space -Integration of distributed devices based on RT-Middleware", IEEE, AROB'07, pp.183-186, 2007

[27] Kotoku, Tetsuo: "Robot Middleware and its Standardization in OMG" in International Conference on Intelligent Robots and Systems (IROS'06) Workshop on Robotic Standardization, Beijing, China, 11-13 Oct. 2006

[28] Bowlby J (1969). Attachment and Loss. vol. I. Attachment, Basic Books, New York

[29] Wickler W (1976). The ethological analysis of attachment. Sociometric, motivational and sociophysiological aspects. Z. Tierpsychologie, 42, 12-28.

[30] Ainsworth, M D S (1969). Object relations, dependency and attachment: A theoretical review of the infant-mother relationship. Child Development, 40, 969-1025

[31] Topál, J., Miklósi, Á, Csányi, V. 1998. Attachment behaviour in the dogs: a new application of the Ainsworth's Strange Situation Test. J. of Comp. Psych. 112, 219-229.

[32] Topál, J., Gácsi, M., Miklósi, Á., Virányi, Zs., Kubinyi, E., Csányi, V. 2005. The effect of domestication and socialization on attachment to human: a comparative study on hand reared wolves and differently socialized dog puppies. Animal Behaviour 70, 1367-1375.

[33] Gácsi, M., Topál, J., Miklósi, A., Dóka, A., Csányi, V. 2001. Attachment behaviour of adult dogs (Canis familiaris) living at rescue centres: Forming new bonds. Journal of Comparative Psychology, 115, 423-431

[34] Rajecki, D, W, Lamb, M, E, Obmascher P 1978. Toward a general theory of infantile attachment: a comparative review of aspects of the social bond. The Behavioral and Brain Sciences, 3, 417-464.

[35] Peters, M., A., Hemmi, J, M., J. Zell, 2007. Signaling against the Wind: Modifying Motion-Signal Structure in Response to Increased Noise. Current Biology, 17, 1231–1234

[36] Szabó Csanád István, Róka András, Gácsi Márta, Miklósi Ádám, Baranyi Péter, Korondi Péter, “An Emotional Engine Model Inspired by Human-Dog Interaction”. In: Proceedings of the 2010 IEEE International Conference on Robotics and Biomimetics. Tianjin, China, Kína, 2010.12.14, pp. 567-572.

[37] Kovács Sz., Vincze D., Gácsi M., Miklósi Á., and Korondi P., (2010) Fuzzy automaton based Human-Robot Interaction, IEEE 8th International Symposium on Applied Machine Intelligence and Informatics (SAMI), pp 165-169.

[38] Tamás Kifor Tibor Gottdank, Ákos Hajnal, Péter Baranyi, Brúnó Korondi, Péter Korondi Smartphone Emotions Based on Human-Dog Interaction, 2nd CogInfoCom Conference Budapest 2011