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Interaction between Vleo and Pleo, a virtual social character and a social robot

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***Abstract*— In this paper we explore the field of human robot interaction (HRI) by adding a new non-physical player in the interaction rather than only humans and robots. It is a proven fact that physical robots enhance the immersion perception compared to only virtual agents. Thus, we created a shared environment with a Pleo Robot and a Virtual Pleo Robot, which we called Vleo, connected through a server to explore this new paradigm in order to see if the engagement during the interaction is improved in intensity and duration. A straightforward set of interactions between Pleo and Vleo have been designed to create narratives and therefore, tested with a group of 8-12 year old children. Results from the test suggest that virtual social robots are a good way to enhance interaction with physical social robots.**

I. Introduction

The goal of social robots is to interact and communicate with humans thanks to their shape, behavior and interaction capabilities. Both physical embodiment and artificial intelligence have been evolving since 90s achieving great advances in the field of social robots. Some examples of advanced social robots are AIBO [24], Pleo [12] or NAO [1].

When children play with Pleo, Pleo gesticulates, moves and makes sounds, in turn, children touch and talk to Pleo. This set of actions define the scope of the interaction within Pleo and children. Clearly, not only what a Pleo could do has implications for the interaction, it is also lacks a degree of naturalness of its embodiment, physical movements and reactions. For example, Pleo is randomly behaving and suddenly a child touches or talks to it, Pleo does not perform a comprehensive or reactive movement or sound with the proper timing and expression as a consequence of the child input. In these cases, children's engagement lowers, because it is like Pleo fails at sensing children demands. There are several examples in the literature [3] [15] that suggest the use of physical agents to enhance engagement and long-term interaction between humans and robots.

So, we propose to introduce new elements in the human robot interaction in order to enrich it, without the constraints of the physical world that reduce the immediacy in interaction. Our proposal is to include augmented reality (AR) virtual characters. So, to that effect, we create Vleo. Vleo is a virtual Pleo, it has the same appearance, but it is more expressive because its movement is not limited by the quantity of servos or their speed of movement. In this context and from the child point of view Pleo and Vleo can clearly communicate between them. Based on this, we hypothesize that the relation between the physical and virtual world is believable and as a consequence, we have created communication rules between them.

We define Vleo as a virtual social robot. This new virtual robot is based on the smart avatar concept [2]. Smart avatars are augmented reality characters linked to real objects. This link is an internet connection that allows a new kind of interaction between characters and objects. Smart avatars can react to objects changing their states and vice versa. Up to now, smart avatars interact with very simple objects (i.e. a lamp). Interactions with smarter objects (like a robot) is one of the goals of this paper. Moreover, it is really challenging to introduce some kind of tangible control on AR characters due the virtual nature of it. In order to design a virtual robot as Vleo we implemented two features: a physical controller [8] and interaction with smart objects.

Fig. 1. Pleo and Vleo interaction system is formed by a physical cube, a tablet (where Vleo is visualized) and a Pleo.

In this manner, we create a shared environment so called ecosystem. In order to enable their coexistence, apart from Pleo, we use a tablet facing the child that enables the AR visualization of Vleo, and also a physical cube. The cube is the physical representation of Vleo that leads children to control it by gesturing with it. This setup is shown in Figure 1. In order to establish a relation between Pleo and Vleo, we have created narrative situations based on both characters behaviors, that are capable to perform actions and express

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emotions through movements and sounds. Then, we have addressed a user test to explore the engagement intensity and duration of this new interaction paradigm with a group of of 8-12 year old children. Although being an early prototype, promising results make us confident that we still have a long way to go in this research area.

II. Related work

Pleo [12] is an autonomous toy robot modeled and bioinspired on a one-week-old Camarasaurus dinosaur. Originally created by Ugobe, it has been bought by Innvo Labs who are continuously developing it. Since its appearance in the industrial market, several researchers in the field of social robots have performed different studies that focus on understanding human-robot interaction [14][20][19][7] [10], exploring ways of interaction with Pleo [16][22] [5] or how to increase the engagement/interaction where playing with Pleo by adding digital content [6][9][23], and others.

A. Interacting with Pleo

Most users interact with Pleo using common physical and verbal communication. Kim et al. [16] studied how untrained users talk to Pleo in order to teach it how to perform some tasks. They realised that users use strongly positive and negative affective prosody when talking to Pleo. The fact that users act in this way spontaneously suggests a high degree of empathy between users and Pleo. In our work we have not considered speech as input, although it could be added to enrich future work.

Ryokai et al. [22] introduced a mixed physical and virtual authoring environment in order to enable children to create stories acted out by Pleo. They introduce tangible tools used for symbolic and abstract manipulations in storytelling. A set of colored cards each with an assigned programmed behavior are used to drive Pleo by putting them in front of it. In that manner, children decide what behavior Pleo performs and when. We also use tangible interaction to drive the storytelling, but it is used to drive Vleo, and its operation is very different due to the differences of the controllers.

B. Interacting with Pleo and digital content

Past research involving Pleo only considered the user and the Pleo as interaction elements (with the exception of [22] that introduces physical cards). Because of this, robotic pet are not capable of engaging users for extended periods of time. This is where virtual content comes in. In [6] they extend the identity of Pleo by creating a virtual representation of it on a mobile device. In a similar way, Gomes et al. [9] addresses two versions of Pleo, a virtual and a physical one. However, they consider a migration between the two embodiments in order to strengthen the idea that both versions are the same entity. Later, Segura et al. [23] did a further examine migration effects. They show how seemingly subtle variations on the migration process can affect the children's perception on the character and its embodiments, although, they argue that there are a lot of unsolved design and implementation challenges for migration process.

In our case, we benefit from digital content which enhances and boost the interaction between Pleo and children. However, we do not consider adding more embodiments to Pleo, or to extend the experience in different platforms such as mobile devices. Alternatively, we propose to add more Pleos with the shape of virtual characters in the interaction experience. Furthermore, we want both worlds to coexist in time and space. Thus we create a mixed reality experience where elements from different worlds, real and virtual interact.

III. Interaction design

A mixed reality space for Pleo and Vleo has been designed in order to enable interaction between them. This type of spaces allows users to interact with both physical and virtual objects in real time. Thus, Pleo (physical) is an autonomous agent, it moves and acts driven by artificial intelligence. On the other hand, Vleo (virtual) is controlled by the child. This point is important because children can decide what Vleo has to do. We chose this to emphasize the relevance of the children in this experience. Based on this, we can summarize the flow in interaction in Figure 2. For controlling Vleo we introduce a tangible object, a cube. This is very similar to what has been done in [8], the of which details are further explained below. The cube connects the virtual and the physical spaces providing more awareness in spatial perception versus a touchscreen interface, also enhancing the sense of immediacy to the user in interaction. So, by moving and gesturing with the cube, children can precisely choose Vleo behavior. As a consequence, Pleo reacts to what Vleo demands. Therefore, children can observe how Pleo reacts to Vleo, closing the interaction loop. For that purpose, we have designed a Vleo-Pleo interaction and a User-Vleo interaction.

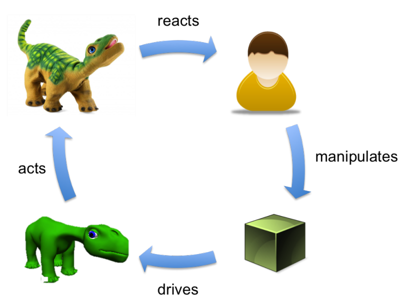

Fig. 2. Interaction flow system. A user manipulates a physical cube that drives a virtual character. This virtual character controls a robot and the user perceives the robot's reactions.

A. Vleo-Pleo interaction

Pleo reacts to Vleo behaviors. So, Vleo begins any narrative situation between them. In order to create a relation between Vleo and Pleo that can be understood by children and, even more fundamentally, that Vleo and Pleo can express, we have chosen basic actions and emotional states.

Vleo can perform three actions: idle, throwing kisses or shouting. Additionally, Pleo can be in three emotional states: neutral, happy or angry. So, Vleo actions trigger Pleo emotional states. The affect of Vleo's actions in Pleo states are shown in Figure 3. As logic suggests, when Vleo is throwing kisses, Pleo's emotional state moves from angry to happy. On the contrary, if Vleo is shouting, Pleo's state moves from happy to angry. However, if Vleo is doing nothing (idle), Pleo does not react and remains in the current state. In this manner, we create a continuous and comprehensive relationship between Pleo's emotional states and Vleo's actions.

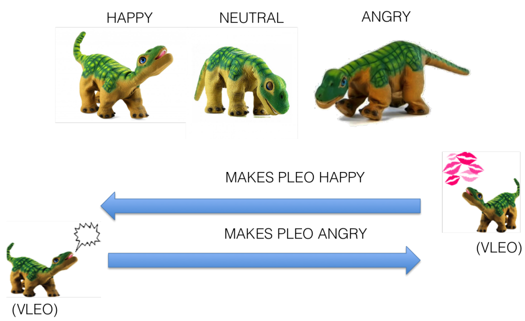

Fig. 3. Vleo-Pleo interaction. Vleo makes Pleo happy when it is throwing kisses, so Pleo's emotional states shifts from angry to neutral and happy emotional state. Contrarily, Vleo makes Pleo angry when it is shouting so Pleo's emotional state shifts from happy to neutral and angry.

B. User-Vleo interaction

As we have explained, Vleo is a virtual character driven by a child. The way a child moves and controls Vleo is by moving a cube. So, we define an interaction system formed by a cube, a tablet and a plane surface. The tablet is placed on a stand in portrait position. The cube is visible to the camera of the tablet. So, the interaction area is located in front of the screen, between the child and the tablet. The cube is our virtual character controller and at the same time our AR marker. So, Vleo appears inside the cube when it is detected. In this manner, augmented reality becomes tangible and controllable from the moment Vleo is included in the view of the tablet's front camera.

Each of the faces of the cube represent one of the actions that Vleo can perform. The top face indicates the current action. This is similar to [8] where the rotation of the cube over the plane where it is placed allow us to define parameters that describe the current action. These parameters define the intensity of the actions. By rotating the cube in a clockwise direction, the intensity of the animation increase; otherwise, by rotating the cube in a counter clockwise direction, we can decrease this intensity. Is it important to note that each time the cube changes its upper face, the intensity of the action is reset to the average value.

IV. Implementation

In order to carry out the interaction design, several software applications have been developed to manage Vleo, Pleo and to communicate them.

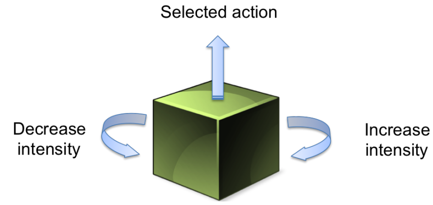

Fig. 4. The orientation and the movement of the cube controls Vleo animation. By rotating the cube it is possible to increase or decrease the intensity of the selected action, which it is indicated by the upper face.

A. System

The communication between Pleo and Vleo has been done through a server. This server is connected to Pleo and Vleo with different protocols, being a TCP/IP protocol for communicating with Vleo and Bluetooth protocol for communicating with Pleo. In this way, we put all the logic of the Vleo-Pleo interaction on the server.

B. Vleo

Vleo's controller has been implemented with Unity [26] game engine, as it enables graphic rendering and skeletal animation from Mecanim [25] animation system. To track the physical cube, we use Vuforia Unity Extension [21].

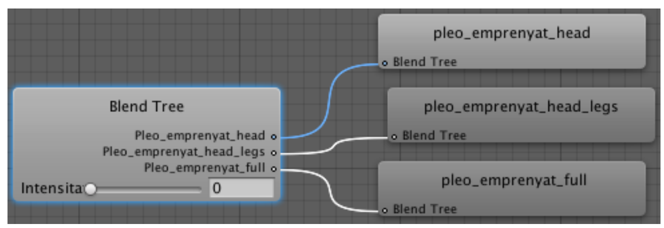

Fig. 5. The blend tree used to animate Vleo during shouting action.

As we have mentioned, we want Vleo to perform different action states: idle, throwing kisses and shouting. For this purpose, we have constructed a behavior controller composed of three states. The Idle state is a unique loop motion, and the other two states are analogous blend trees (see Figure 5). Both are composed of three loop motion clips, each progressively more intense. So, kisses and shouting state actions range from less active to more active head and leg movements. To manage the different intensity of each motion when motion blending occurs, we use a weight parameter that ranges from -1 (less active) to 0 (neutral) and 1 (more active), which defines the amount of activation of each state. This parameter is inferred by computing the increase or decrease of the cube orientation over the plane, setting to 0 each time that the cube is placed over the plane with a different face. We set two full turns of the cube to change the weight parameter from -1 to 1.

We design the cube for recognition and control purposes. Figure 6 illustrates the constructed prototype. The cube represents actions in its faces. Each action has two faces. In this manner, we teach to children how to place the cube in order to control Vleo. Moreover, we have textured the

Fig. 6. The constructed physical cube to drive Vleo. Their faces are illustrated with Pleo images that represents the actions that Vleo can perform.

background of the cube faces in order to improve robustness of image recognition.

C. Pleo

Pleo's connectivity has been enhanced through the bluetooth module RN-41 that allows Pleo to communicates with the server. To improve the connectivity range we have attached an additional antenna. Finally, we have embedded everything in a box below Pleo's stomach as an extension of its body.

As it is known, Pleo can behave according to its operating system or a coded behavior that lies in a miniSD card. So, we have coded a .ply script which includes the three mentioned Pleo states (happy, angry and neutral). Each one is represented by unique loop motion clip and a sound.

V. Experiment Design

We have conducted an experiment with children in order to verify our interaction proposal. We target it children between the ages of 8 to 12 as Ugobe does with Pleo users.

A. Hypothesis

The hypothesis of the study was focused on the classic HCI usability evaluation factors (ISO 92411-11 [13]), that is: efficiency, effectiveness and user satisfaction. These three factors will be evaluated as follows:

1) The cube controller for Vleo is easy to use for 8-12 year old children.
2) 8-12 year old children understand and realize the interaction between Vleo and Pleo.
3) 8-12 year old children enjoy their time by playing with Vleo and Pleo.

B. Procedures

The experiment was performed in three different phases: familiarization, practice and test. Before starting the experiments with Vleo and Pleo, the children and the experimenter took part in a familiarization phase. The goal of this phase was to get acquainted with the children to know Pleo and Vleo actions. First, the experimenter lets the children play for 2-3 minutes with Pleo. Then, the experimenter spent 1-2 minutes explaining what Vleo is, what the cube is, and how he or she can control Vleo using the cube. Pleo is not present during this explanation.

TABLE I
QUESTIONNAIRE

Question	Answer
'Do you think that Pleo is happy?'	5-point
'Without Vleo, how would you make Pleo happy'	Literal
'Do you think that Pleo is angry?'	5-point
'Without Vleo, how would you make Pleo angry'	Literal
'Do you like to play with Vleo'	5-point and literal
'How do you like to play most?'	Pleo or Pleo-Vleo

After that, children were ask to practice making Vleo throwing kisses or shout. Once all the children understood how to control Vleo the test phase started. Then, in the test the children were asked to complete two tasks: **Task 1:** Make Pleo feel happy; **Task 2:** Make Pleo feel angry. For each task, we let the children control Vleo with no instructions and with a maximum time of 2 minutes. The task finished when the children believed that the goal was accomplished. It is there for possible that they finish it without success.

C. Participants and Settings

The fifteen participants in the experiments were children (11 boys and 4 girls) 8-12 year old. All them enrolled in a summer robotics program organized by La Salle - URL. An experimenter was on a table with Vleo and Pleo to facilitate the test, and to intervene in case of difficulties. He was also involved in the activity as a facilitator of the interaction, providing guidance and ensuring that children did not became frustrated or harmed during the activity.

Fig. 7. The facilitator explaining to a subject how to control Vleo.

The experiment took place in a wide corridor at the university (see Figure 7), in front of the classrooms where the participants were taking the Robotics course. An iPad, a cube and a Pleo were placed on a table. The children were sitting or standing facing the iPad, doing the test one at a time. Two experimenters were present during the test, one with the mentioned role of facilitator, and the other with the role of observer who track results and was in charge of the proper technical performance of the interaction system.

D. Questionnaire and evaluations

We use a questionnaire and a valuation to asses the children's impressions.

- Questionnaire: The questionnaire measured the perception of the children about the accomplishments of the tasks. The questionnaire was asked at the end of the trials, the experimenter records the questions with the children's answers. Some questions used a 5 point Likert-scale and with a space available for literals, providing information not covered by the response categories. The questions are summarized in Table I.
- Evaluations: Experimenters took some evaluations to relate user performance and answers. For each trial it was noted if the task was solved with success or not, and how many time the user needed to perform it (whether the user did it right or not).

VI. Results

The collected data from the questionnaires related to each task is summarized in Figure 9. Unfortunately, we have discarded 3 participants due to technical constraints. In the first task, 91.7% of the participants believed that Pleo was happy by giving the highest rating, the rest (8.3%) believed that Pleo was happy, but not much. In case of the second task, all participants agreed that Pleo was angry without exemption.

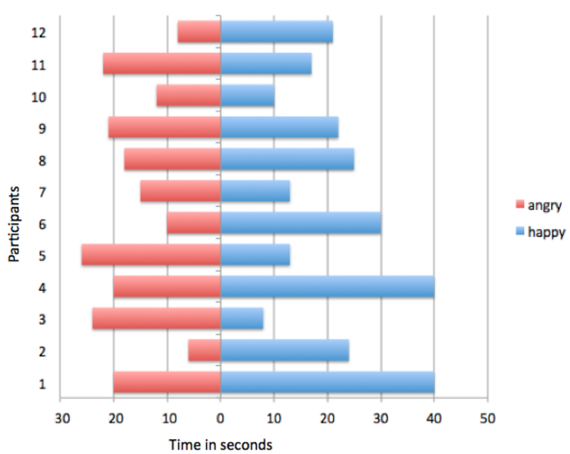

Fig. 8. Time taken to get Pleo happy and time taken to get Pleo angry.

Figure 8 shows the amount of time taken to perform the tasks. We obtained a wide range of values from both. Values range from 5 to 40 seconds in the first task. The average was 22 seconds and a standard deviation of 10,2 seconds. In the second task, values range from 6 to 26 seconds with an average value of 16,8 seconds and a standard deviation of 6,2 seconds. On both tasks, all participants could finish with success. Finally, we summarize the play preference in Figure 9. As shown, a significant majority (83.3%) preferred to play with Vleo and Pleo, otherwise, only a 16.7% prefer to play with Pleo alone.

VII. Discussion

First, the time needed to change Pleo's emotional state is linked with Vleo' control system usability. This change is achieved through setting Vleo's actions and the appropriate

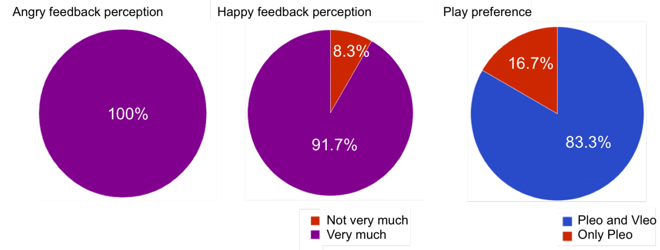

Fig. 9. Happy and Angry feedback perception and Play preference.

intensity. During the test, the experimenters have detected some technical problems and this resulted in high values obtained in the first task proposed. Some users needed more than 25 seconds to reach the objective. It is noticeable that children improved their performance in the second task, as demonstrated by the decrease of the average and standard deviation values, with improvements of 27% and 39 %, respectively. So, the Vleo controller must be adjusted to be easier to use allowing faster execution by decreasing the number of turns of the cube. This will improve execution and facilitate controller operations.

Then, the user perception of Pleo's emotional state slightly depends on the state itself. Happy emotional state is not perceived as clear as angry emotional state. One possible cause of this could be related to the selected animation clip and sound for this emotional state. It seems that representing the angry state is a little easier than the happy state. Still, we can validate our second hypothesis since children always correctly perceived Pleo's and Vleo's behaviors.

In case of play preference, the results are meaningful. More children prefered playing with Vleo and Pleo rather than with only Pleo, as we have addressed in our third hypothesis. A number of different factors may be the cause. One of them could be the Wow effect of the interaction setup. It is not familiar to children to drive a virtual character with a cube. It is even less to visualize this virtual character overlaid on the reality through a tablet camera view. These elements make the experience more innovative, favoring engagement. In addition, the fact that being two characters in the interaction system enables the creation of a more complex scenarios than with only one character, and in this way it prolongs the time of use. This enables more situations and is more challenging for children.

VIII. Conclusions and Future Work

In this work we propose a new way of interacting with social robots, in our case with Pleo dinosaur. We combine together the physical and the virtual world through this prototype. To that effect, we create Vleo, an AR virtual character with the same appearance of Pleo. Then, we put them together in a mixed environment. The distinguishing feature of our work is the relationship between a virtual character and a social robot, which coexist in place and time in the interaction experience, and also they interact between them. As results demonstrated, the introduction of digital content, in this case virtual characters, the interaction between users and robots increased the engagement.

The usage of a physical cube to drive Vleo, a virtual element, in order to interact with Pleo, a physical element, made the relationship between both elements more credible. Indeed, the experience we proposed is similar to traditional puppetry, but giving more flexibility and expressivity in interaction due to the virtual world nature [17] and the presence of Pleo robot.

The interaction design of the presented prototype only regarded two elements: Vleo and Pleo. The Vleo cube was a tangible extension of Vleo virtual character and in this way both form a unit. Accordingly, the interaction experience could be improved by adding more virtual or physical elements. In case of virtual elements, a virtual world could be designed [4]. The freedom of creation that virtuality offers is the main difference between a Vleo-Pleo interaction and a Pleo (with any type of remote controller)-Pleo interaction. Although in this work it has been presented an early prototype, there are many possibilities to boost the interaction through the creation of virtual entities. In case of physical elements, a set of tangible objects could be used for representing virtual entities ready to be animated in the virtual world [11]. This kind of improvement will lead to complex and collaborative tasks that involve new elements (physical or virtual) to be operated by Pleo and/or Vleo. The experience will be more rich and more open to the creation of new narrative situations.

In addition, a future line of work will include using more Pleo robots and Vleo cubes. Thus, several changes must be applied to the current interaction system. Using a bigger display could lead to have more Pleos and Vleos in the same location without decreasing the usability by avoiding interfering with other users. Conversely, if we use the remote control no need for more space. Several children could control their Vleo in their places, and they could visualize other Pleos and Vleos through their virtual windows (e.g. tablet screens or larger displays). Furthermore, the inflow of more characters (both virtual and physical) creates the need to monitor them potentially through a cloud computing system like proposed in [18].

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References

[1] Aldebaran. Nao robot: Intelligent and friendly companion. http://www.aldebaran.com/en/humanoid-robot/nao-robot. May 2015.

[2] J. Amores, X. Benavides, M. Comín, A. Fusté, P. Pla, and D. Miralles. Smart avatars. In *IUI 2014 Workshop on Interacting with Smart Objects*, 2014.

[3] J. W. H. E. S. K. Bainbridge, Wilma A. and B. Scassellati. The benefits of interactions with physically present robots over video-displayed agents. In *International Journal of Social Robotics 3, no. 1*, pages 41–52, 2011.

[4] A. R. Chaturvedi, D. R. Dolk, and P. L. Drnevich. Design principles for virtual worlds. *MIS Quarterly*, 35(3):673–684, 2011.

[5] A. Curtis, J. Shim, E. Gargas, A. Srinivasan, and A. M. Howard. Dance dance pleo: developing a low-cost learning robotic dance therapy aid. In *Proceedings of the 10th International Conference on Interaction Design and Children*, pages 149–152. ACM, 2011.

[6] J. Dimas, I. Leite, A. Pereira, P. Cuba, R. Prada, and A. Paiva. Pervasive pleo: long-term attachment with artificial pets. In *Mobile HCI*, 2010.

[7] Y. Fernaeus, M. Håkansson, M. Jacobsson, and S. Ljungblad. How do you play with a robotic toy animal?: a long-term study of pleo. In *Proceedings of the 9th international Conference on interaction Design and Children*, pages 39–48. ACM, 2010.

[8] A. Fernández-Baena and D. Miralles. Avatar: Tangible interaction and augmented reality in character animation. In *IUI 2014 Workshop on Interacting with Smart Objects*, 2014.

[9] P. F. Gomes, E. M. Segura, H. Cramer, T. Paiva, A. Paiva, and L. E. Holmquist. Vipleo and phypleo: Artificial pet with two embodiments. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology*, page 3. ACM, 2011.

[10] M. Heerink, M. Díaz, J. Albo-Canals, C. Angulo, A. Barco, J. Casacuberta, and C. Garriga. A field study with primary school children on perception of social presence and interactive behavior with a pet robot. In *RO-MAN, 2012 IEEE*, pages 1045–1050. IEEE, 2012.

[11] R. Held, A. Gupta, B. Curless, and M. Agrawala. 3d puppetry: A kinect-based interface for 3d animation. In *Proceedings of the 25th Annual ACM Symposium on User Interface Software and Technology*, UIST '12, pages 423–434, New York, NY, USA, 2012. ACM.

[12] Innvo Labs. Pleo world. http://www.pleoworld.com, May 2015.

[13] International Organization for Standardization, Geneve, Switzerland. ISO 92411-11: Ergonomic requirements for office work with visual display terminals, Part 11: Guidance on usability, 1998.

[14] M. Jacobsson. Play, belief and stories about robots: A case study of a pleo blogging community. In *Robot and Human Interactive Communication, 2009. RO-MAN 2009. The 18th IEEE International Symposium on*, pages 232–237. IEEE, 2009.

[15] C. D. Kidd and C. Breazeal. Robots at home: Understanding long-term human-robot interaction. In *IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 3230–3235. IEEE, 2008.

[16] E. S. Kim, D. Leyzberg, K. M. Tsui, and B. Scassellati. How people talk when teaching a robot. In *Human-Robot Interaction (HRI), 2009 4th ACM/IEEE International Conference on*, pages 23–30. IEEE, 2009.

[17] P. Marshall, Y. Rogers, and M. Scaife. Puppet: a virtual environment for children to act and direct interactive narratives. In *2nd international workshop on narrative and interactive learning environments*, pages 8–15, 2002.

[18] J. Navarro, A. Sancho-Asensio, C. Garriga, J. Albo-Canals, J. Ortiz-Villajos Maroto, C. Raya Giner, C. Angulo Bahón, D. Miralles, et al. A cloud robotics architecture to foster individual child partnership in medical facilities. In *Cloud Robotics Workshop in 26th IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2013.

[19] S. Paepcke and L. Takayama. Judging a bot by its cover: an experiment on expectation setting for personal robots. In *Human-Robot Interaction (HRI), 2010 5th ACM/IEEE International Conference on*, pages 45–52. IEEE, 2010.

[20] K. Pitsch and B. Koch. How infants perceive the toy robot pleo. an exploratory case study on infant-robot-interaction. Second International Symposium on New Frontiers in Human-Robot-Interaction (AISB). The Society for the Study of Artificial Intelligence and the Simulation of Behaviour, 2010.

[21] Qualcomm Connected Experiences, Inc. Vuforia Unity Extension https://developer.vuforia.com/downloads/sdk, May 2015.

[22] K. Ryokai, M. J. Lee, and J. M. Breitbart. Children's storytelling and programming with robotic characters. In *Proceedings of the 7th ACM Conference on Creativity and Cognition*, pages 19–28. ACM, 2009.

[23] E. M. Segura, H. Cramer, P. F. Gomes, S. Nylander, and A. Paiva. Revive!: reactions to migration between different embodiments when playing with robotic pets. In *Proceedings of the 11th International Conference on Interaction Design and Children*, pages 88–97. ACM, 2012.

[24] Sony. Aibo. http://www.sony-aibo.co.uk/, May 2015.

[25] Unity. Mecanim: Simple and powerful animation technology. https://unity3d.com/unity/editor, May 2015.

[26] Unity. Game Engine. http://unity3d.com/, May 2015.