



New Dog New Tricks

Human-Robot Interaction and Appearance
Design of a Ball Playing Robot

Yi-reh Tzeng

New Dog New Tricks

Human-Robot Interaction and Appearance Design of a
Ball Playing Robot

Yi-reh Tzeng (Ray Tzeng)

Submitted in partial requirement for the Degree of Master of Arts (M.A.)

Under the supervision of

Prof. Dennis Paul

Prof. Dr.-Ing. Udo Frese

The project is financed with DFKI funds.

Digital Media Master Program

University of the Arts Bremen, Germany

28th January 2013

Acknowledgements

I would like to give the biggest gratitude to my parents, who have been my inspiration to study abroad. Thank you for your love and support.

I am very thankful to Professor Dennis Paul and Professor Udo Frese for giving me this chance of a lifetime. This has truly been a dream come true.

A big thank you to Kyoung-Eun Hong and Friederike Otto for their job on constructing the garment. Nadine Jochens, thank you so much for helping me with the photo documentation.

Declaration of Authorship

I hereby certify that this master thesis entitled “New Dog, New Tricks: Human-Robot Interaction and Appearance Design of a Ball Playing Robot.” is entirely my own work except where otherwise indicated. Passages and ideas from other sources have been clearly indicated.

1.Motivation.....	5
2.Introduction	11
3.Appearance Design	15
The Uncanny Valley	16
Design Strategy	18
<i>The Backstory</i>	18
<i>The Development</i>	18
<i>Introducing Doggy</i>	19
<i>The Requirements of the Design</i>	19
The Results	20
4.Interaction Design	27
Introduction	29
Doggy’s Classroom-- The Animator.....	30
<i>Gesture Structure</i>	30
<i>File Format</i>	31
<i>Input Device: Wii Classic Controller with Wiimote</i>	32
<i>Input Software</i>	32
<i>The Interface</i>	32
<i>Recording</i>	33
Behavior Architecture	34
<i>Behavior Structure</i>	35
<i>The interface</i>	35
<i>Simulation Mode</i>	36
<i>Edit Mode</i>	37

<i>The Results</i>	38
5. Conclusions	41
Summary	42
Learning from the Collaboration.....	42
Outlook	43
6. Documentation of the Appearance Design	45
Breakthrough in Appearance Design	46
Making of the Fur	46
Testing.....	47
Placing the camera	48
7. Documentation of the Interaction Design	51
Programming Environment.....	52
Implemented Library	52
Tested Environment.....	52
Known Incompatibilities	52
Challenges and Solutions	53
8. Bibliography	55
9. Appendix	57
List of Materials and Sources	58
Source Code	59

1.Motivation



Figure 1 Piggy exhibited at the Cebit 2011 in Hannover

In the winter semester 2011, I got an opportunity of making the appearance design of a robot called Piggy. It was created with one simple function: Recognizing a ball and hitting it back. The design challenge was to give the robot an enclosure, so that the viewer would not have to face a machine, but to face a robot to play ball with.

As a result I designed a comic figure that has a big nose like a pig's snout, since the ball game is called "Piggy". During the Cebit 2012, "Piggy" got positive feedback, where mostly children and female audiences were enthusiastic about playing with this blue cuddly robot. Compared to other robots showing at the Cebit in 2012, which mostly had a plastic body, Piggy stood out by having the appearance of a stuffed animal. (*Figure 1.*)

Following the success of Piggy, Professor Udo Frese proposed the idea of me not only making the appearance design, but also the gesture design for the second version of Piggy. This was an opportunity for me to design an appearance, a character, and an identity of a robot. It somehow it brought me on a journey investigate a human- robot relationship.

The day I entered the futuristic building of Cartesium where the laboratory for the robots was, I was hooked again on the topic of robotics. Growing up in Taiwan, I, as most Taiwanese children, watched Japanese Mangas and animations, which were dominated by robotic characters. This was the starting point of my obsession with robots, and probably, of others like me as well.



Castle in the Sky (1986)
Directed by Hayao Miyazaki

Later, I gained interest into a more grown up Animation. “Ghost in the Shell” talks about a world where Cyborgs and Androids live with human. The storyline involves a special troop that investigates hackers in artificial intelligence crimes, and explores the topic whether an artificial intelligence could have as cyborg or human, a soul.

In one of the episode it talks about a programmer, who was so obsessed with a movie character that he hacked into an android, and gave her the character and the dialogue of a movie role. After watching that episode, I couldn't help but wonder can a human really love a machine? Or even more provocatively, can a machine love a human? Could they have a romantic relationship?

To understand this question better, I was eager to learn what artificial intelligence is about

and where its limit is. Interestingly, in the computer history of the 60s, the goal was to make the computer understand the human by words. An example would be ELIZA¹. She is a chatbot who basically fishes out the world that the user were typing in, and using the keywords asking questions back to the user. Although the machine had little to no understanding what the user was saying, users gave positive feedback; they felt like they were being heard. ELIZA even continued in research for therapeutic practice further on.

In 1999 AIBO² was introduced. It is a cyberdog that can sense your touch and give some basic gestures as feedback. Many researches evolved from AIBO, studying real dogs behavior toward AIBO, even how kids react differently toward real dogs and AIBO.

When discussing human relationship with robotics, Paro³ is probably one of the most famous robots. Many users, especially elderly were intrigued by its innocent, and fluffy appearance. Paro gave one thing that many human couldn't: Undivided attention. Where often human or pets would be limited by its physical strength, Paro had patience like no living creature could have. Paro was so successful, that it even got into practical therapy use.

¹ Joseph Weizenbaum. 1966

² Sony. 1999

³ Takanori Shibata. 2001

2.Introduction

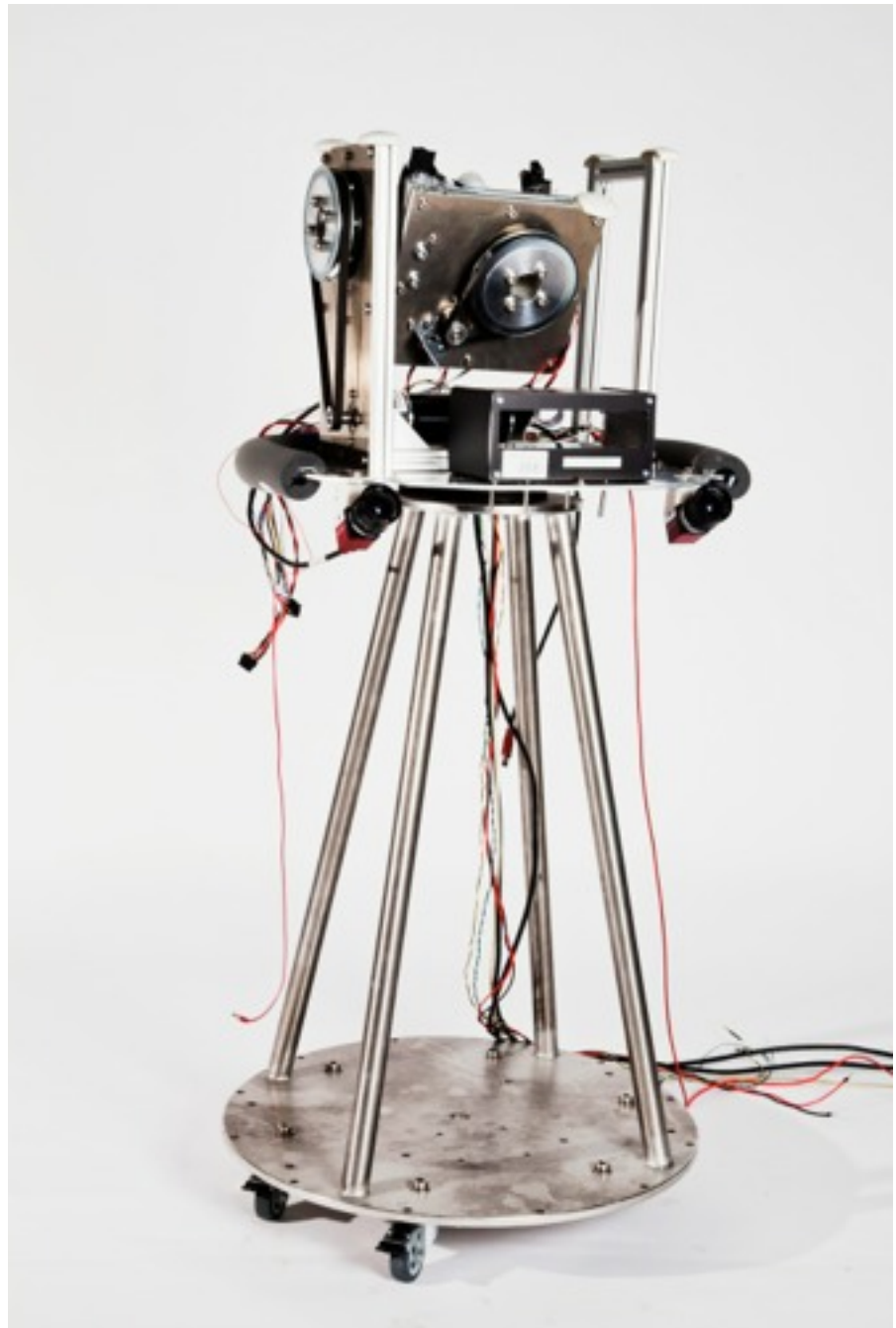
Robots have been wildly used in many different fields, from mars exploration, future iPhone's production, to welcoming visitors in museum. Our central character in this thesis-- Piggy is an event robot, whose goal is to entertain people, and earning money by doing this. The target from the beginning on is for commercial purpose, and hopes to become a star of birthday parties and other celebrations.

Piggy is part of the project "B-Human"⁴, which focuses on researches of ball playing robots. By using a set of stereo camera, Piggy is able to recognize a ball, calculate its movement, and hit it with another bigger ball, which is connected with a bat to motors. The ball recognition, mechanical control, and engineering design of Piggy is developed by professors and students of the Computer Science department of University of Bremen, and researches in the DFKI Cyber Physical Systems.

In this thesis, the appearance design and human-robot Interaction design of the second version of Piggy is being presented. The thesis will introduce the development of the design process, as well as documenting the production of a working appearance design. For the human-robot interaction design, two programs will be introduced, which present the human robotic interaction design in software simulation.

This master thesis is a collaborative project with the Digital Media Department of University of Arts Bremen, and the Computer Science Department of University of Bremen.

⁴ <http://www.b-human.de/>



Second version of Piggy without the skin and bat

3.Appearance Design

3.1. The Uncanny Valley

In 1970, Masahiro Mori proposed a graphic that would illustrate the feeling a person when facing a robot that has human look and other specific characteristics. As in Figure 2, the graphic shows two curves: One for moving characters (dashed line); one for still characters (full line). According to Mori's observation, the more human alike the robot becomes, the more familiar and favorable it grows to the viewer, until it hits one point around 80~85 % where "the Uncanny Valley" appears: The familiarity drops rapidly, and the viewer starts to feel uncomfortable until faced with a real human.⁵

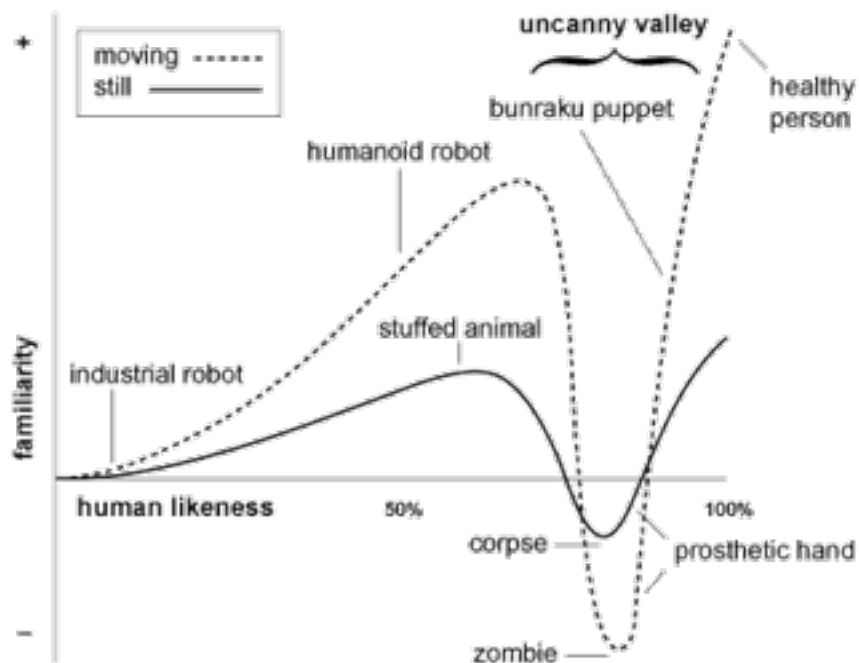


Figure 2 The Uncanny Valley.

⁵Mori, Masahiro "Bukimi no tani (the Uncanny Valley)". *Energy*, 7, 1970 ,p 33–35 (Translated by MacDorman, Karl F. and Minato, Takashi).

It is the awkward zone where robots do not look like a machine, neither like a human being. Mori uses a zombie as his example that would fall into the lowest point in the figure in the “moving” curve, and a corpse in the “still” curve.

3.2. Design Strategy

3.2.1. The Backstory

Back in 2011, when I first got the chance to design Piggy 1.0, I was not aware of the Uncanny Valley. Little did I know, Piggy 1.0 fulfilled Mori's hypothesis, where stuffed animals were at the peak of the curve, although in our case, Piggy is also a moving object.

3.2.2. The Development

Following the appearance design strategy of Piggy 1.0, the goal of the second version was to keep its nature of stuffed puppet, as well as be at the top of the Uncanny Valley. Therefore, the appearance design of the robot remained simple shaped, and the goal of the movement was not to become a realistic animal or human, rather a cartoon or fictional character.

The first idea of Piggy 2.0 would be a stuffed puppet with a humanoid shape. The strategy was to fit Piggy 2.0 in the top of the left curve of uncanny valley by becoming a mixture of humanoid and stuffed animal.

In the development, the living puppet, "Pinocchio" became a source of inspiration. Much like a robot, Pinocchio was created as a human companion, has a shape of a human, he moves like a human, and thinks he is a human, but misses one thing-- the conscience, whereas the robot misses the soul.

As poetic the inspiration may sound, the path to creating the final outcome in this concept was a challenge. One if taking to literally was from Pinocchio the impression of telling a lie, which was not the intention and focus. Also to my surprise, the design reminded viewers of a "Gartenzwerg", which is porcelain dwarf decoration often seen in the gardens of German suburbs.

3.2.3. Introducing Doggy

Due to design limitation of the robotic arms and their proportion compared to the body, the design strategy developed from stuffed humanoid puppet back into stuffed animal like Piggy 1.0. Having this stuffed animal strategy decided, we thought about enhancing the human-robot interaction by creating a more familiar and playful situation. The character of a standing dog seemed to fulfill these requirements; therefore it became our final target. The name of the second version of Piggy became Doggy for obvious reasons.

3.2.4. The Requirements of the Design

As the famous saying goes “form follows function.” It could not be more vital when it came to the appearance design of this robot. In a matter of fact, the functional mechanics were already defined when I was approached for the design task. In order to fulfill the design requirement, the exterior look had to adapt to various factors:

- Specific Height:

The robotic arm needed to measure 221.7 cm in height in order to engage in a game with an average height adult.

- Mobility:

The robot arm needed to be able to have freedom in 3 axes movements, therefore the enclosure needs to be flexible.

- Integration of camera lenses:

The camera needed to be at the height of 63.5 cm, and positioned underneath the robotic arm.

- Security and Ventilation:

The Design should protect the camera from impact, also to protect users from catching their fingers into the moving joint. Also, since the computer will be placed inside of the robot, therefore, it needs to a shaft for ventilation.

3.3. The Results

In order to make the robot expressive, the body was designed to cover the whole robotic arm, making the hitting sphere the head of the dog, and the moving joint the waist. This allowed Doggy to move forward, bend aside, and turn around (*Figure 3&4*). A tail with motors that have two degrees of freedom was added later because dogs express many emotions through their tail. (*Figure 5*)



Figure 3 Doggy bending over

Figure 4 Doggy's movement from side view





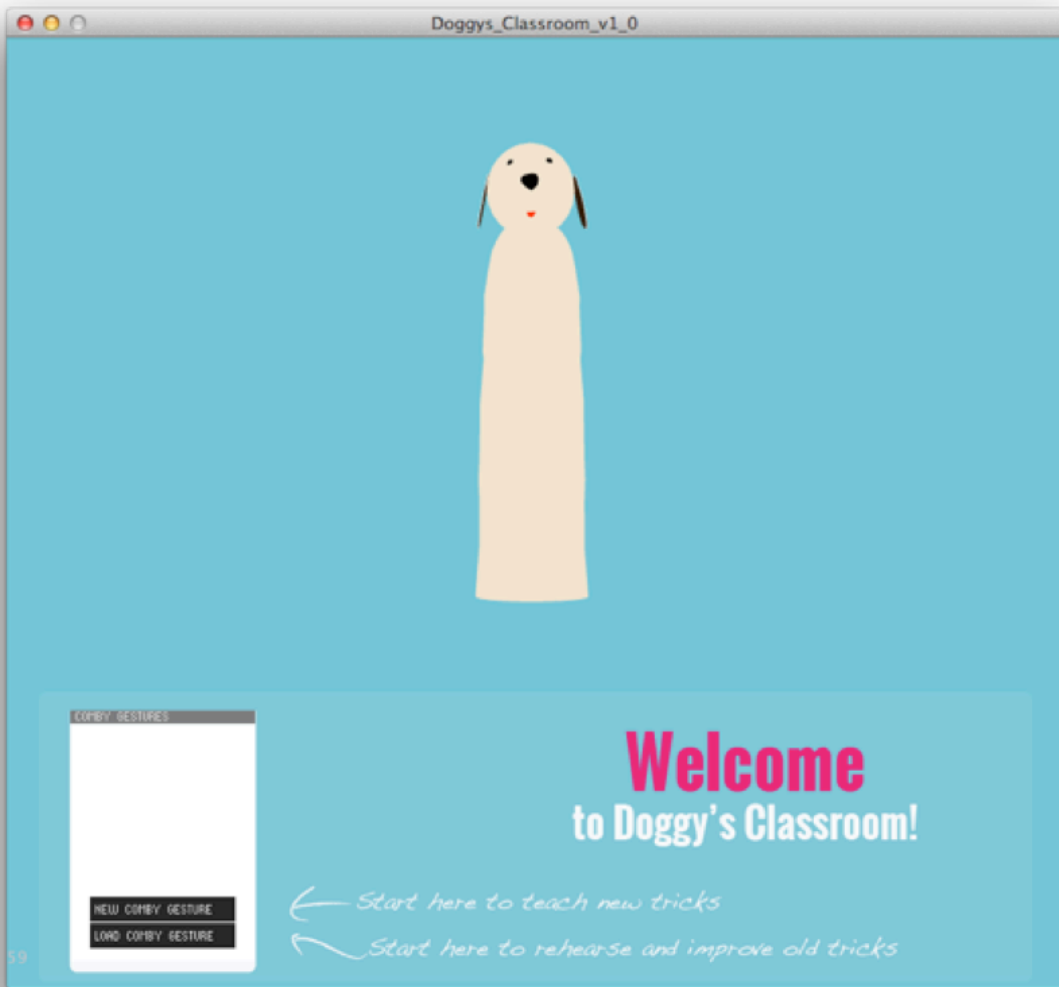




Figure 5 Doggy wiggling its tail



4. Interaction Design



Welcome Screen of "Doggy's Classroom"

4.1. Introduction

Although most publications in Human-Robotic Interaction are in the field of Computer Science and Engineering, this multidisciplinary subject has given opportunities for collaborations between artists and scientists.

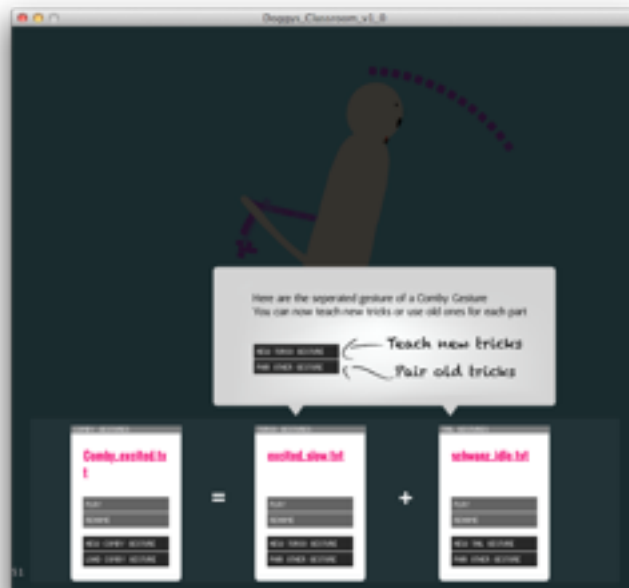
The MIT Media Laboratory published at the Human-Robot Interaction Conference in 2010 a report about artist collaborating in giving the robot an expressive and dynamic behavior⁶. In the report, an Animator, a Behavior Architect and Robot designer worked together and documented the challenges of integrating these three fields.

The Tools

For the Human-Robot Interaction of Doggy, I designed and created two programs in order to record gestures and assign it to behaviors. Learning from the collaborations report mentioned above, “Doggies Classroom” is an authoring tool for animators, and “Behavior Architect” is for the behavior architecture and simulation of the robot in action.

⁶ Gray, Jesse, Hoffman, Guy, Adalgeirsson, Sigurdur, Berlin, Matt, and Breazeal, Cynthia, “Expressive, Interactive Robots: Tools, Techniques, and Insights Based on Collaborations.” in *What Do Collaborations with the Arts Have to Say About Human-Robot Interaction ? Papers from the 2010 HRI Workshop* p24-31, 2010

4.2. Doggy's Classroom-- The Animator



Menu of “Doggy’s Classroom” where animators can record and pair different gestures.

4.2.1. Gesture Structure

Since there are two different moving body parts on the robot, a gesture consists of a combination of a torso and a tail gesture. In Doggy’s Classroom, this combination is called a “comby gesture”. (Figure 6)

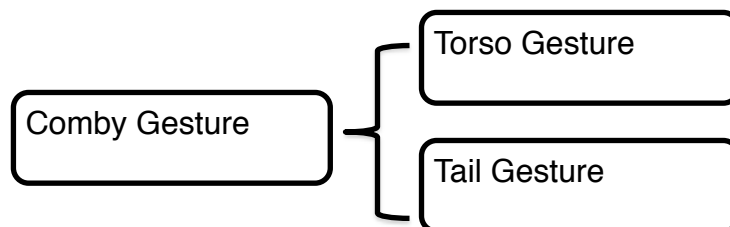


Figure 6 The gesture structure of a comby gesture

The structure allows the animator to mix and match a torso gesture with tail gestures from another comby gesture.

4.2.2. File Format

The comby gesture, torso gesture and tail gesture will be saved as *txt* files. The comby gesture stores in the first line the filename of the torso gestures and then stores the filename of the tail gesture. In the second line, the behavior name will be saved. This however, will be saved and edited in the “Behavior Architect” and not in Doggys Classroom.

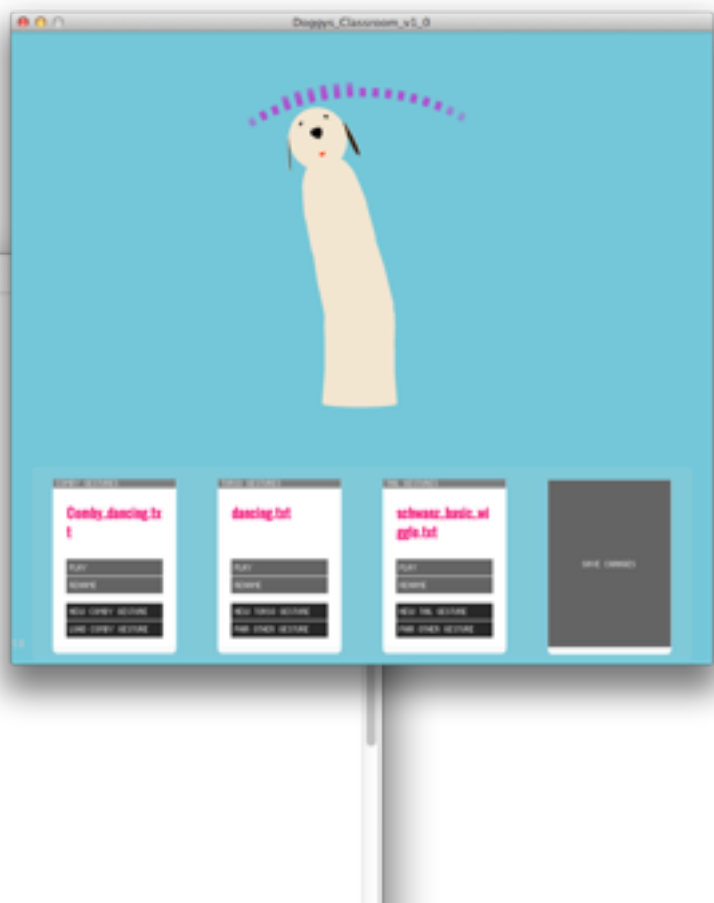
The recording of the tail and torso gesture will be stored with the time in milliseconds, followed by x, y and z coordinates. (Figure 6& 7)

An example of a torso Gesture where Doggy is dancing.

Figure 6 A screenshot of the torso txt file.

```
dancing.txt
0, 0, 0.0032265186, 0, 0, -0, 0.05543995
32, 0, 0.0032265186, 0, 0, -0, 0.114106536
48, 0, 0.0032265186, 0, 0, -0, 0.172773
67, 0, 0.0032265186, 0, 0, -0, 0.23143959
100, 0, 0.0032265186, 0, 0, -0, 0.29010606
166, 0, 0.0032265186, 0, 0, -0, 0.34877264
183, 0, 0.0032265186, 0, 0, -0, 0.4074391
267, 0, 0.0032265186, 0, 0, -0, 0.29010606
283, 0, 0.0032265186, 0, 0, -0, 0.23143959
300, 0, 0.0032265186, 0, 0, -0, 0.172773
316, 0, 0.0032265186, 0, 0, -0, 0.05543995
350, 0, 0.0032265186, 0, 0, 0.0032265186
400, 0, 0.0032265186, 0, 0, 0.061893186
416, 0, 0.0032265186, 0, 0, 0.12055957
450, 0, 0.0032265186, 0, 0, 0.17922616
466, 0, 0.0032265186, 0, 0, 0.23789263
485, 0, 0.0032265186, 0, 0, 0.35522592
500, 0, 0.0032265186, 0, 0, 0.41389227
519, 0, 0.0032265186, 0, 0, 0.47255886
617, 0, 0.0032265186, 0, 0, 0.41389227
632, 0, 0.0032265186, 0, 0, 0.35522592
649, 0, 0.0032265186, 0, 0, 0.2965592
666, 0, 0.0032265186, 0, 0, 0.17922616
684, 0, 0.0032265186, 0, 0, 0.12055957
700, 0, 0.0032265186, 0, 0, 0.0032265186
780, 0, 0.0032265186, 0, 0, -0, 0.05543995
832, 0, 0.0032265186, 0, 0, -0, 0.172773
868, 0, 0.0032265186, 0, 0, -0, 0.23143959
888, 0, 0.0032265186, 0, 0, -0, 0.34877264
927, 0, 0.0032265186, 0, 0, -0, 0.4074391
936, 0, 0.0032265186, 0, 0, -0, 0.4661057
970, 0, 0.0032265186, 0, 0, -0, 0.52477205
1000, 0, 0.0032265186, 0, 0, -0, 0.4661057
1120, 0, 0.0032265186, 0, 0, -0, 0.34877264
1137, 0, 0.0032265186, 0, 0, -0, 0.23143959
1154, 0, 0.0032265186, 0, 0, -0, 0.114106536
1169, 0, 0.0032265186, 0, 0, -0, 0.05543995
1186, 0, 0.0032265186, 0, 0, 0.0032265186
1255, 0, 0.0032265186, 0, 0, 0.061893186
```

Figure 7 he torso txt file played on screen



4.2.3. Input Device: Wii Classic Controller with Wiimote⁷

The Wii Classic Controller was used as an input device, because it has two joysticks that allow animators to control four dimensions at the same time. In order to send signals to the computer, the Wii Classic Controller was connected to the Wiimote.

The Wiimote was taken under consideration as input device because of its motion sensing ability in three axes, but there was a technical difficulty to analyze the *yaw* value due to the drifting issue. Although there are solutions to overcome this by either analyzing the gyroscope and accelerometer, or using the IR sensor as reference, the Wiimote was designed for game play, and the solutions would be only sufficient for moments, but not for animations.

The multitouch ability, built-in accelerometer and gyroscope of mobile devices such as mobile phone or tablets would be also suitable as input devices. Due to time issues, this option was not further explored and is taking into future plans. In fact, the interface of “Doggy’s Classroom” was designed with having haptic interface in mind, and since the program was developed in Processing, it is not far from being transferred to Android by using Processing API.

4.2.4. Input Software

⁸Osculator 2.12 was used to receive the signals from the Wii Controller with Bluetooth, and was sent via OSC to “Doggy’s Classroom”.

4.2.5. The Interface

The interface consists of an interactive 3D model of Doggy, and a panel underneath which is the major interface for the animator to record, load and pair gestures. On top of the 3D model, a box is shown to represent each recorded milliseconds. The higher the opacity of the box, the recent it is in the sequence.

⁷ Nintendo. 2006

⁸ <http://www.osculator.net/>

4.2.6. Recording

Rather than making the animation based on a timeline interface, “Doggy’s Classroom” is designed as a recording studio, where the animator is like a director, making multiple takes, and decides the best one to work with. (Figure8)

Having had experiences using Adobe Flash and 3D Animation Applications like Autodesk 3D Max, I often had the impression it would be more efficient to animate a model by making real time capturing than working on a timeline. Because the timeline cannot give a direct sense of the motion when adjusting the keyframes, the animator has to replay the sequence multiple times to evaluate the animation. Therefore, making real time recording is more intuitive and efficient for this scenario.

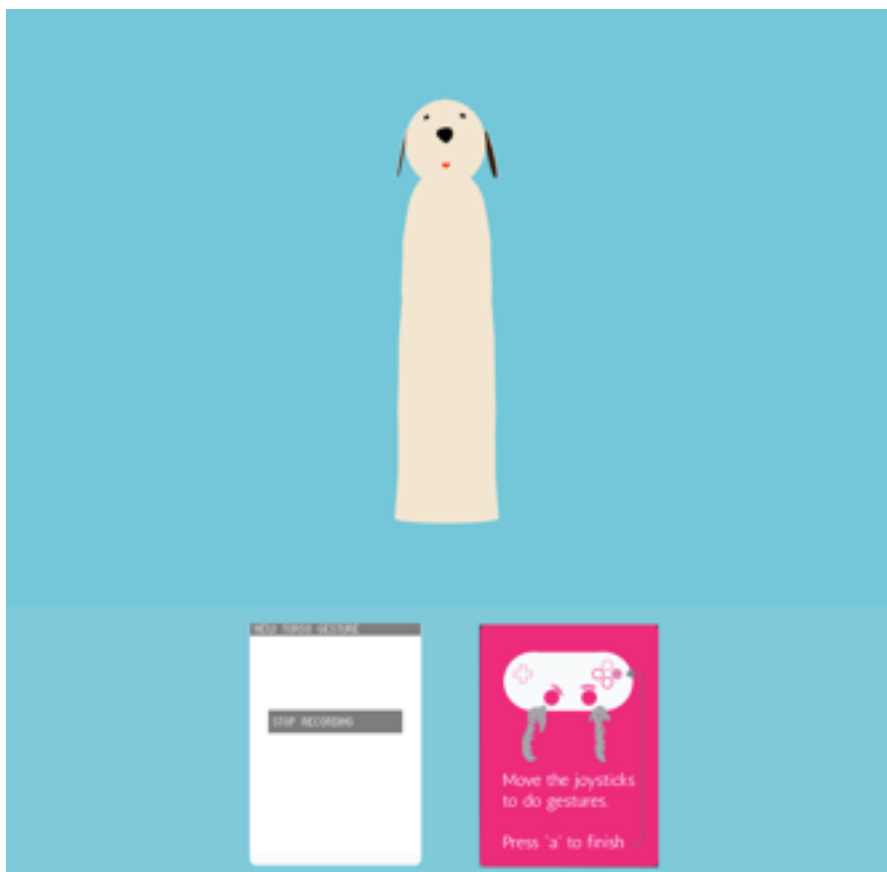


Figure 8 (partial) Screenshot of the recording interface in "Doggy's Classroom"

4.3. Behavior Architecture

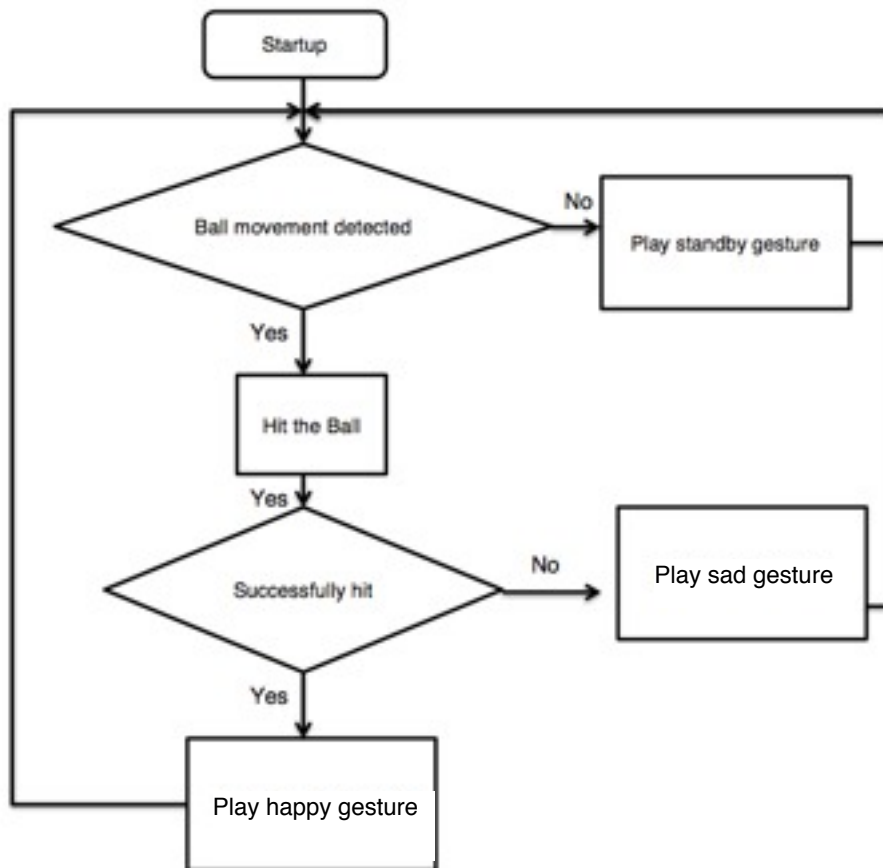


Figure 9 The flowchart of the behavior architecture

4.3.1. Behavior Structure

As shown in Figure 9, the behavior architecture of Doggy is structured in three scenarios: happy, sad, and standby. Happy gestures will be played when the robot hits the ball, sad when it doesn't, and standby when it is still waiting for the ball to be thrown.

4.3.2. The interface

Inheriting the interface from Doggy's Classroom, the Behavior Architecture consists of an interactive 3D model of Doggy, and a panel underneath. The panel has two modes: the simulation and the edit mode.



Figure 10 A screenshot of the simulation mode in behavior architect

4.3.3. Simulation Mode

The simulation mode demonstrates the behavior of Doggy in a simulative ball game, where the behavior architect can play with Doggy in a virtual room. Whenever a behavior gets activated, a random gesture will be played from the according behavior group. (Figure 10)

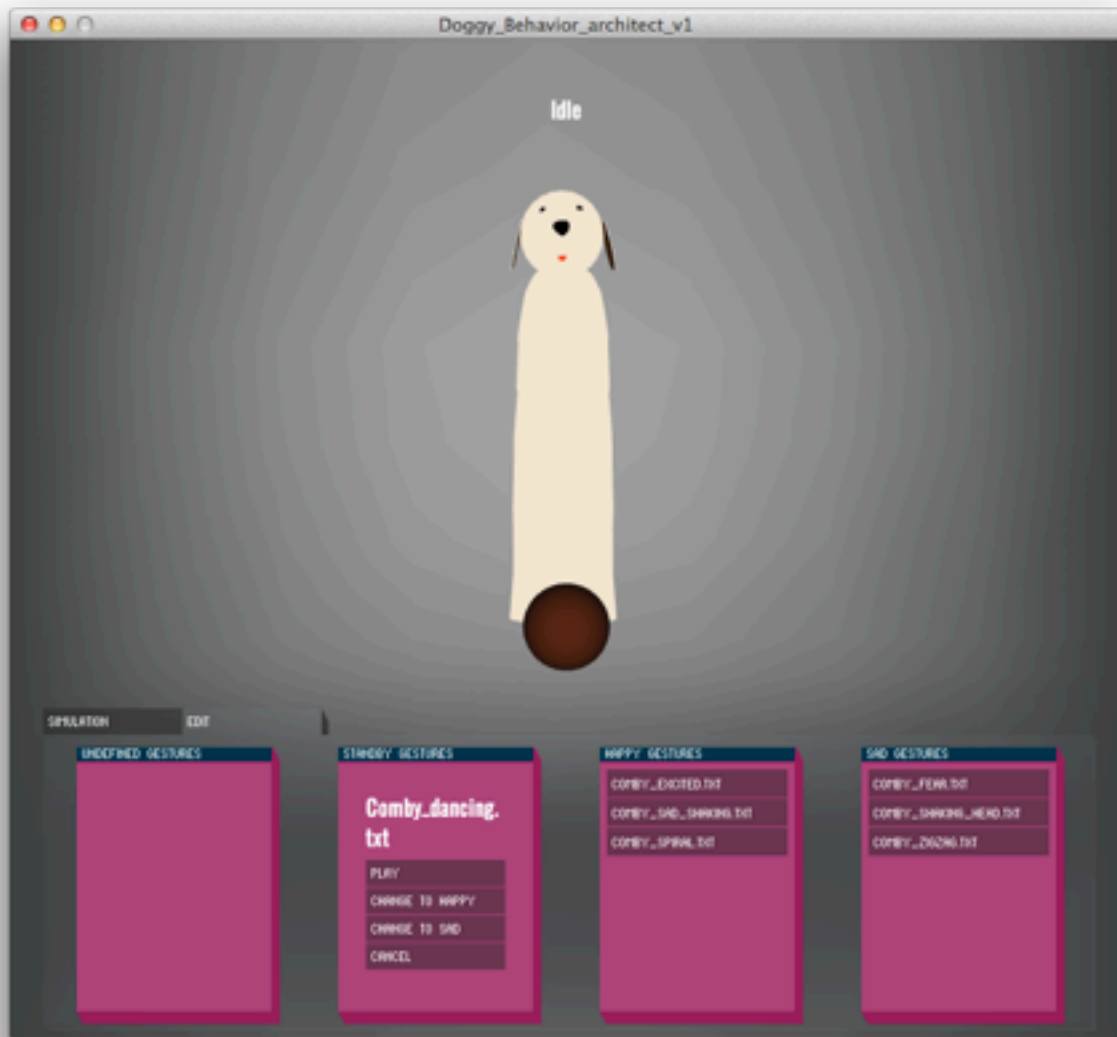


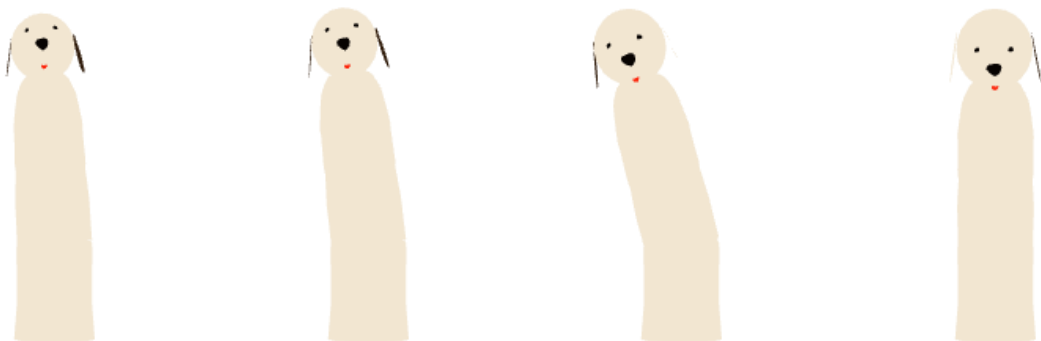
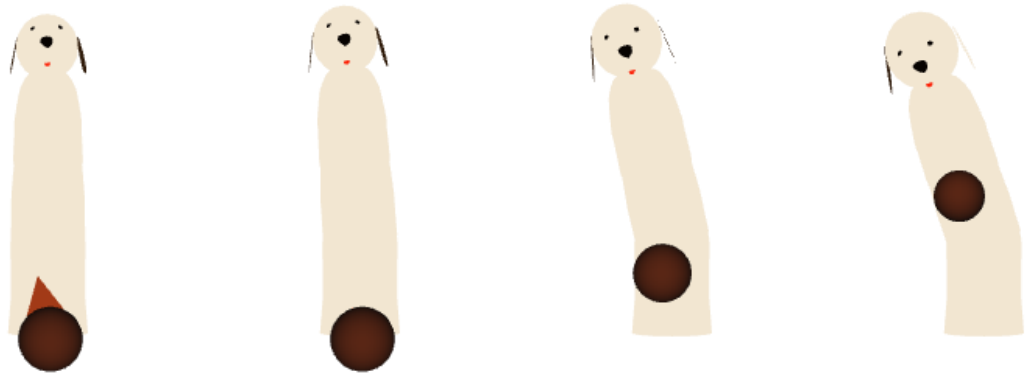
Figure 11 A screenshot of the edit mode in behavior architect

4.3.4. Edit Mode

The Edit mode is the tool for behavior architect to assign each comby gesture to happy, sad or standby. (Figure11)

4.3.1. The Results

As shown in Figure 12, doggy is able to trace the ball that the user thrown in the simulation mode and play a random gesture of the behavior. In the example of Figure 13, Doggy was able to hit the ball, therefore playing a dancing gesture, which was defined as a happy behavior in the edit mode.



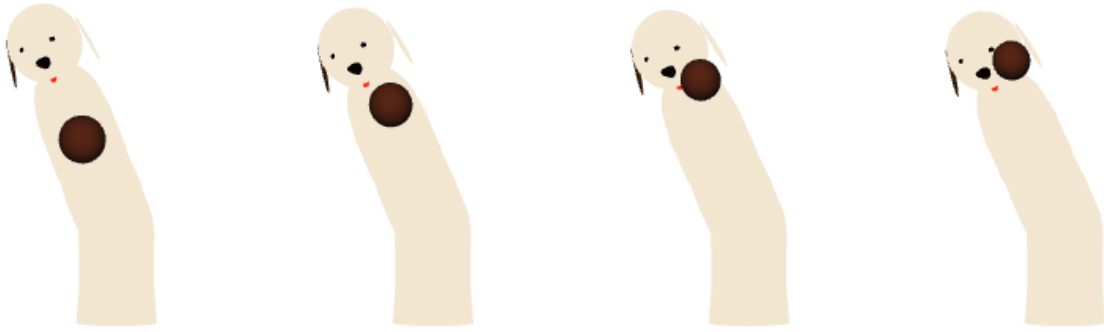


Figure 12 Doggy found the ball and hits it with the head.

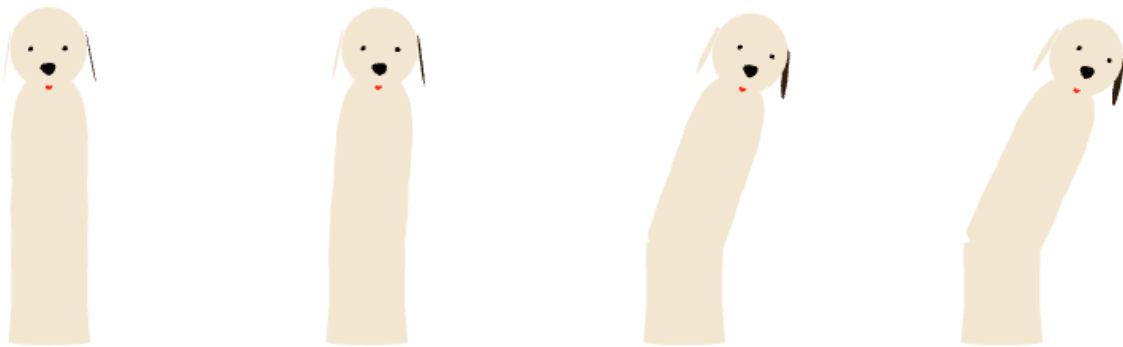


Figure13 To celebrate the success, Doggy dances around.

5. Conclusions

5.1. Summary

Doggy, a ball playing robot dog has been introduced as a descendent to its first version, Piggy. It follows the same appearance design strategy, and has the advantage of a moving torso and tail. The appearance design was produced and tested in motion on the robot frame. As a result, Doggy is able to express itself to the players with pre-recorded gestures as body language in a simulated environment.

5.2. Learning from the Collaboration

5.2.1. The communication

The execution of the design concept was a multidisciplinary collaboration between media design, computer science, fashion design and integrated design.⁹ Because of the different vocabulary of each field, the most common way of communication was to stand in front of the robot frame to point and tell. Regardless of which profession each came from, seeing a problem in the physical world was the most efficient way of understanding each other.

5.2.2. The bigger the choice, the harder to choose

Compared to the first version of Piggy, Doggy's appearance design, frame building, and motor controlling took longer than planned. The fact that the appearance design delayed, was because of the unstable structure inside the of the hollow torso. The undefined shape resulted in having little to no reference points when constructing the skin of doggy, and had to be taken into altering frequently. Also, the exposed motors inside of Doggy's skin caused several problems not only in the shape, but also security issues.

Looking back on of the first version Piggy, where a lower IKEA shelf was used for the frame, the construction of Piggy 1.0, I realized only took three months. Whereas in the second version, where we build the frame by ourselves, it took six month instead. It could be easily described as a German saying: "Wer die Wahl hat, hat die Qual" (The bigger the choice, the harder to choose.) The custom design for Doggy gave us unlimited possibilities, but also made the choice harder, resulting in delays.

⁹ a more detailed description can be viewed in 6.0 Documentation of the Appearance Design

5.3. Outlook

For future development, the implementation of the gestures with the skin on the robot is the first goal. Also, as discussed in 4.2.3 Input Devices, plans of using mobile devices as input control, or as control device are taken into consideration. As for upgrades in “Doggy’s Classroom”, easing and stabilizing the record function, also keyframe based recordings are next on the list.

6.Documentation of the Appearance Design

6.1. Breakthrough in Appearance Design

Because the robotic arm was almost longer than the body, it was hard to overcome the challenge – that started when designing Piggy 1.0 – of making the robotic arm logical in appearance. In Piggy 1.0 the solution was to hide the robotic arm in a hat, which would not work in this case because of the Gartenzwerg confusion.

There was no easy workaround of embedding the robotic arm into the design, and the process was stuck in development for weeks, until on a trip in Prague, a standing porcelain cat with a bubbly rounded head gave an inspiration for possible solution. Instead of making the robotic arm an accessory, why not making it a part of the figure?

6.2. Making of the Fur

In order to execute the appearance design of Doggy, Kyoung-Eung Hong, a former fashion design student of University of the Arts Bremen, and Friederike Otto, student in Integrated Design also from the University of the Arts Bremen, were hired for sewing and constructing the skin of Piggy.

Material

The material of the enclosure had to be light so that the robotic can carry it, at the same time, flexible to give the three axis motor freedom to perform.

The exterior made of fabric was chosen as a material not only because of the stuff puppet concept, but also because of its weight and flexibility.

Unfortunately, at the time when the robot was being designed, most of the fabric store carried majorly summer textile. After weeks of search, a plush fabric was found.

Structure

In order to give the fabric a structure, we experimented with different possibilities. IKEA's hanging texture basket was the starting point.

We used rings made out of glass fiber vertically sewn into the inner fabric to support the shape. This did not measure up to the expectation though, because the result became sharply edged instead of the bullet shape originally designed.

Another attempt was to create a spiral structure similar to the laundry basket. We sewed a spiral tunnel into a rounded fabric cylinder. After the first fitting, the structure was close to sketch, except the shoulder part where one side didn't had any support from the glass fiber and appeared empty. Due to the asymmetric attribute of the spiral shape, we attached an extra glass fiber ring to the shoulder height. Two alterations later, the construction was finally finished.

6.3. Testing

When we had the first test with the motors, we found out that the construction was still too heavy for the motor to lift. To solve this issue, we shortened the robotic arms by 26,5 cm. However this does not totally fix the issue of being too heavy for the motor, since the motor was not designed to carry weight, but for playing ball only. The strength of the motors which was planned before the appearance design started, was set for an amount of strength that would hit the ball, yet not put any players in danger.

When the master thesis was close to finish, the implementation of the ball-playing module in Doggy hasn't been finished yet. It was, however, enough to perform gestures.



6.4. Placing the camera

In Piggy 1.0, we had a big advantage by designing the camera directly as the eyes. Later when we were still at the idea of Pinocchio, the solution was to hide the camera in a big pair of headphones. For Doggy, both couldn't be possible. Because the head is now at the end of the robotic arm, the camera shouldn't be at the target of the balls, and certainly should not be moving frequently.



A first attempt was to place the camera inside of a pair of boxing gloves, which should be hanging from the neck as an accessory. Not only could the gloves protect the cameras from impact, it could also give the robot a sporty style.

It was decided later to use a belt instead of the gloves, because a hanging pair of boxing gloves would not be logical at the height where the camera would be.

7.Documentation of the Interaction Design

7.1. Programming Environment

Processing 2.0b6 was used to program both “Doggy’s Classroom” and the behavior architect

7.2. Implemented Library

- PeasyCam v105
for Camera Rotations
- OscP5 0.9.5
for receiving Wiimote signal via Osculator
- ControlP5 0.7.5
for creating User Interface

7.3. Tested Environment

“Doggy’s Classroom” and the behavior architect were tested on Mac OS X 10.8.2 Mountain Lion. Since Processing is based on Java, the processing sketches should be also compatible with Windows or Linux. However, the input software Osculator is only compatible on OS X, therefore the recording function can only be used on an Apple computer that has Bluetooth built in.

7.4. Known Incompatibilities

- The sketches are not compatible with Processing1.x, because of the new implementation of loading an .obj 3D model which is only supported in Processing 2.x.
- Incompatibility with the newest version of Control P5:
Since the newest version of Control P5 is having conflict with the mouse wheel handler of PeasyCam, it was decided to use older version of ControlP5.

7.5. Challenges and Solutions

As mentioned in 6.4, there were many issues in working with different versions of library. The biggest issue though, was the upgrade of Mac OSX 10.8, where a different authorizing method for Bluetooth devices was used. As a result, previous Wiimote libraries in Processing could not be implemented, and Osculator became the solution.

8. Bibliography

Gray, Jesse, Hoffman, Guy, Adalgeirsson, Sigurdur, Berlin, Matt, and Breazeal, Cynthia.
“Expressive, Interactive Robots: Tools, Techniques, and Insights Based on Collaborations” in *“What do Collaborations with the Arts Have to Say About Human-Robot? Papers from the 2010 HRI Workshop”* 2010 p 24-31

Mori, Masahiro. “Bukimi no tani (The Uncanny Valley)”. *Energy*, 7(4), 1970 pp.33-35.
Translated by MacDorman, Karl F. and Minato, Takashi.

9. Appendix

9.1. List of Materials and Sources

- Textile of Doggy:

5169 Hil-Tex Beige

Mikropolar Fleece

Available at

Kraft-Stoff

0421/79 29 169

Vor dem Steintor 119

28203 Bremen

- Glass Fiber:

P21

Available at

Drachenschwärmer Flügge & Meyer E. Kfm.

0421/ 328044

Ostertorsteinweg 58

28203 Bremen

9.2. Source Code

The source code of “Doggy’s Classroom” and “Behavior Architecture” are included in the CD-ROM.