Animal Controlled Computer Games: Playing Pac-Man against Real Crickets

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Abstract. We explore the possibilities of replacing behaviour-generating code in computer games by real-time behaviour of live animals, and the question of whether one can play computer games against animals. To experience the differences for a human between playing against an animal or against computer code, we experimented with a variant of Pac-Man where the behaviour of virtual game characters is derived from that of live crickets in a real maze. Initial results are described in this paper.

1 Introduction

When I was young I loved to play games with my cat. Throwing a ball across the room which it would chase, letting a ball of wool bungle above its head which it would try to grab, or putting food in a difficult place for it to reach, seeing if it could manage to get it. You never knew how the cat would react or what it would do. It could play the game along, get aggressive, find new ways to solve its problem, or simply loose interest.

These days I play games against a computer. These games take you to different worlds and tell unbelievable stories. But what they fail to do, is to surprise me, like my cat would. Computer games are pre-programmed, and will not do anything except what their programmers programmed them to do. If the programmer did not think of it, it can not happen. Donkey Kong (Nintendo, 1981) will never get tired of throwing heavy barrels at you, or strain a muscle, or get hungry and just eat the princess. After playing a computer game for some time, you know what you can expect from it.

But is it possible to take the unpredictability of an animal, and merge this behaviour with a computer game, by this replacing parts of the computer code by animal behaviour? Can you play a computer game against an animal? What will be the differences? In this study, we will explore these questions and their possibilities.

2 Playing Computer Games against Animals

While searching for relevant projects and research on the question if you can play computer games against animals, no direct comparison was found. However, there is an art project made by Dan Young called "Lumberjacked"[1], which enables you to play a computer game against a tree. With the aid of sensors, movement of the leafs of the tree are translated into movement within the game.

We could not find direct examples of playing computer games against animals. But when we look at the three keywords of this question, namely computer, games and animals, we can make interesting combinations. The combination computer-games needs no further research; it is a standard term. Lets have a look at the other ones.

2.1 Animals and Games

It is quite common for humans and animals to play games together. This can be voluntary and enjoyable for the animal, like a dog fetching a stick. But it can also be forced upon the animal, like bullfighting. From the bulls viewpoint this is not play.

Animals do not need humans to stimulate them to play games. Many animals show natural play behaviour. It is not easy to tell if an animal is playing or not, because animal play may imitate adult behaviour so closely it is difficult to make a distinction between them. However, there are clear examples of animal play[2,3]. A common example has young lions wrestling, trying to overpower each other.

2.2 Animals and Computer Games

It is possible to learn animals to play computer games. After learning Rhesus monkeys to manipulate a joystick and perform computerized game-like tasks[4], animals such as pigs and rats[5] followed. Computer games can act as a platform for comparative research, permitting direct comparison of performance by humans and for example primates, with identical software and hardware under equal conditions.

Not only can animals learn to play computer games, some even enjoy playing them. Research with Rhesus monkeys found that they actually prefer game-like computer tasks above their normal toys, and replace boredom related behaviour[6]. It is not clear what precisely makes the game-like tasks enjoyable to the monkeys.

2.3 Merging Computers and Animals

With the AIBO, Sony introduced an “entertainment robot” in the shape of a dog (1999). It tries to simulate the behaviours of an animal pet, but eliminates the responsibilities and problems of a real pet. It does recognize its boss, likes to play and develops its own “personality”. The purpose of AIBO is actually opposite to the goal of our study. It uses computer code trying to simulate a real animal, while we want to use real animals to perform a task which is usually done by computer code.

Instead of making a robotic representation of an animal, it is also possible to keep the representation digital. In 1996 the Tamagotchi was released by Bandai; a handheld digital pet, which you have to play with and feed through button operations.

Another approach is to let an animal control a computer. Artist Ken Rinaldo’s “Augmented Fish Reality”[7] is an installation of 5 robotic fish-bowl sculptures with Siamese fighting fish inside of them. By swimming to an edge of the bowl, the fish moves the sculpture in the corresponding direction. This lets the fish get within a centimetre of each other, allowing the normally aggressive fish to interact without killing each other and explore their environment beyond the limits of the fish-bowls.

Garnet Hertz created "The Cockroach Controlled Mobile Robot"[8]. It consists of a giant hissing Madagascan cockroach, which controls the movements of a three-wheeled robot. The cockroach is placed above a pingpong ball, which it spins with its feet, like a trackball device. When the robot detects an object ahead, one of many small lights which encircle the front of the cockroach starts to flash. As the cockroach tries to scuffle away from the light, the robot moves away from the obstacle.

The "Augmented Fish Reality" project puts the fish in direct control of the robot, it moves in the direction the fish is facing. Hertz's project has a slightly different approach: it is hard to say if the cockroach is controlling the robot, or if the robot is controlling the cockroach. The robot is moved by the movement of the animal, but the sensor-driven lights influence the direction the animal is moving in.

The previous two projects already get close to creating a cyborg, an organism which is a mixture of organic and mechanical parts. At the Duke University Medical Center, researchers even went a step further in accomplishing this. Here they taught a Rhesus monkey to consciously control the movement of a robot arm in real-time, using only direct signals from its brain and visual feedback on a video screen[9].

The opposite can also be found, namely an electrical device controlling an animal[10]. Isao Shimoyama, head of the bio-robot research team at Tokyo University, developed a way of controlling a cockroach with a remote control.

3 Using Animal Intelligence in Pac-Man

Our goal is to see if it is possible to replace behaviour-generating computer code by animal behaviour. We will not focus on making it a "pleasing" (as implied when playing a game) experience for the animal. We want to concentrate on the differences in playing against an animal or against computer code. To test this, we replaced the "artificial intelligence" part of a computer game by "animal intelligence".

The computer game we used for our experiment is "Pac-Man" (Namco, 1980). This is a well-known game, which gives us the advantage that people already have expectations of how the game should play. Also, if we designed our own game there is a risk that the game itself is judged, rather than the replacing of computer code by animal behaviour. In "Pac-Man" you control a character trapped in a maze full of small dots. If you eat all the dots, the level is finished. Four ghosts wander in the maze, you lose one life when they touch you. There are four power-up items, which when eaten scare the ghosts, giving Pac-Man the temporary ability to eat them.

Instead of computer code, we want to have animals controlling the ghosts. To enable this we built a real maze for the animals to walk around in, measuring 20x20x1,8 cm. Its proportions and layout match the maze of the computer game. The position of the animals in the maze is detected using colour-tracking, and linked to the ghosts in the game, which let the real animals directly control the virtual ghosts.

Our "Pac-Man" game is not an exact copy of the original game. The maze is smaller, so you are more likely to encounter the ghosts. When a ghost gets eaten it is not temporarily locked in the middle of the maze. Instead it changes in a blinking pair of eyes, indicating that it was eaten. Furthermore there are no bonus-fruits.

3.1 Crickets

While choosing which animal to use we made some practical decisions. The animal could not be too large. The larger the animal, the larger the maze would need to be. This costs more money, takes more time to build and requires more space. This time and effort would be better spent testing and doing research. Furthermore, the animal should not be too hard to find. Decease of an animal should not give problems finding a replacement. It should also be fairly active. Lack of movement will result in lack of resistance for the player in the game. We were not especially looking for an intelligent animal, since it is not our goal to learn an animal how to play a game. The field cricket (*Gryllus campestris*) complies very well with these requirements and therefore became our test subject. It measures 18-27mm and has a dark brown or black colour.

In their natural environment crickets prefer to sit together during daytime. The strongest ones sit in the middle, being more protected against predators. Since crickets are cold-blooded they get more active with high temperatures, around 33° Celsius is preferred. When hungry, crickets search for food, otherwise the males will try to lure and impress females by singing loudly.

3.2 Game Play

The natural behaviour of crickets is very apparent when they are controlling the ghosts. Just after being placed in the maze, they are very active, probably because they are agitated. After inspecting the maze individually they are likely to find a place to group together. This had a strong effect on our game-play. While being agitated, their speed is so fast that it is hard to avoid them, but when they group together they stop moving, which makes it possible for Pac-Man to eat most of the dots in the maze unhindered. However, this also makes it impossible to eat the dots on the place where they sit, preventing the player from finishing the level. Only by eating a power-up one is able to eat the ghosts, and therefore also the remaining dots. While grouping together gives the crickets protection in nature, in our virtual game it results in the opposite, making it easy to eat all the ghosts in one go.

In contrast to the fixed speed of the original Pac-Man ghosts, the movement of the crickets is very unpredictable, sometimes making short stops, and continuing with a different speed. Their speed also depends on the temperature inside of the maze, since they are cold-blooded. We could change the speed of the crickets by altering the temperature, this way having different difficulty levels.

4 Feedback to the Animal

Up till now we had one-way interaction: the game play depends on the movement of the animals. But if we want a bit more intelligent game play, the animals should react to the actions within the game also. It is possible to attract or repel an animal with stimuli such as sound, vibration, temperature, pheromones, light, electricity and smell.

Most of these stimuli are not suitable for our game. Once pheromones or a smell are released in the maze, they will be very difficult to control or remove. Heat takes time to increase or decrease, making it a slow stimulus. Using electricity on an animal is rather cruel, and would quite likely result in complaints of animal abuse. Vibration, sound and light can be activated and deactivated very quickly. It is difficult for crickets however to pinpoint a sound in the maze. A possibility is to darken the part of the maze where Pac-Man is located. The crickets are attracted to this dark place, but they must be able to directly see it to know it is there, which is difficult in a maze. Otherwise they will just sit still in the light, hoping not to be noticed by predators.

In nature, vibration of the ground warns crickets for an approaching predator. We chose to use this behaviour to stimulate the crickets in the game. We divided the floor of the maze into six parts, each with a motor attached underneath that vibrates when switched on. When the crickets should chase Pac-Man, we switch on the motors furthest away from his location in the maze, so the crickets will flee in his direction. When Pac-Man eats a power-up, the crickets are supposed to run away from him, so we then vibrate the part of the floor that contains Pac-Man's position.

4.1 Game Play

When we started to play our modified game, the crickets reacted as we expected: they walked away from the vibrations. But surprisingly the crickets quickly got used to the vibrations, they habituated. After a couple of minutes they hardly reacted to them anymore, they seemed to have learned that the vibrations do not pose a threat. Only after making the vibrations much stronger they reacted on them for a longer time. After about half an hour they started ignoring the vibrations again recurrently.

When the crickets react to the vibrations, there is an apparent interaction between the player and the crickets. The ghosts really start to chase or avoid you, depending on the state of the game. Differences again are that the ghosts do not move with a constant speed, but frequently stop and continue with different speeds, and sometimes stop moving at all. When they should avoid Pac-Man, they occasionally run in the wrong direction, walking straight into him. The crickets also manage to go to places where they are not supposed to be. They sit on the walls of the maze, or manage to crawl in-between the top of the walls and the glass covering plate, effectively avoiding Pac-Man.

5 Discussion

With this project we succeeded to play a computer game against animals. It was very tempting to forget our main goal, namely to see what the *differences* are when replacing parts of a computer code by animal behaviour. For example, the crickets easily habituated to the vibrations of the floor. Our first reaction was to increase the strength of the vibration, so they would continue to run away from it. But the fact that the crickets seem to learn that the vibrations are not a threat to them, and that they can safely ignore them, is much more interesting. It is actually a sign that we have some intelligence in our system.

During our tests something else happened which was very intriguing. One of the crickets stopped moving at all, and on closer inspection we discovered it was shedding its skin. The cricket's new skin was very light, and therefore it did not get detected by our colour tracking anymore. We now had a cricket which could freely walk around in our maze, not getting detected by our system, which was still tracking its old skin. After about half an hour the cricket's skin turned dark enough to also be noticed by the colour tracking, resulting in five ghosts being put in the game. At this moment our game really surprised us, you could say the crickets generated an extra piece of code to the game. This kind of unexpected behaviour was exactly what we were hoping to encounter during this research.

For future research it would be interesting to track the animals in a more natural environment. The wooden maze we now use does not provide much stimulation for the animals. A possibility could be to track ants in an ant farm. This way they will not only react on stimuli the player gives them, but they will also have their own natural activities. Or, by using reward schemes, the animal behaviour could be adapted to yield more interesting game play situations.

References

1. Dan Young, Lumberjacked, online resource: www.newdigitalart.co.uk/lumberjacked, 2005
2. Marc Bekoff, John A. Byers, Animal Play: Evolutionary, Comparative and Ecological Perspectives, Cambridge University Press, Cambridge, 1998
3. Robert Fagen, Animal Play Behavior, Oxford University Press, Oxford, 1981
4. Duane M. Rumbaugh, W. Kirk Richardson, David A. Washburn, "Rhesus Monkeys (Macaca mulatta), Video Tasks, and Implications for Stimulus-Response Spatial Contiguity", Journal of Comparative Psychology, Vol 103(1), 1989, pages 32-39
5. David A. Washburn, Michael J. Rulon, Jonathan P. Gulledge, "A new breed of computer users: Rats control a cursor via joystick manipulation", Behavior Research Methods Instruments and Computers, Vol 36, 2004, pages 173-179
6. David A. Washburn, "The games psychologists play (and the data they provide)", Behavior Research Methods Instruments and Computers, Vol 35, 2003, pages 185-193
7. Ken Rinaldo, Augmented Fish Reality, Presented at the Ars Electronica Festival, September 2004, Linz, Austria
8. Garnet Hertz, Control and Communication in the Animal and the Machine (Master's Thesis), University of California Irvine, 2004
9. Jose M. Camena, Mikhail A. Lebedev, Roy E. Crist, et al, "Learning to control a brain-machine interface for reaching and grasping by primates", PLoS Biology, Vol 1, 2003, pages 193-208
10. Isao Shimoyama, Raphael Holzer, "Bio-robotic Systems Based on Insect Fixed Behavior by Artificial Stimulation", International Symposium on Robotics Research (Hayama, Japan), 1997