

# Metazoa Ludens: Inter-Species Computer Interaction and Play

## ABSTRACT

We promote a new type of inter-species media interaction which allows human users to interact with their pet friends remotely via the Internet through a mixed reality based game system named Metazoa Ludens. We examined the effectiveness of this system in a two-pronged approach. Firstly, and most importantly the positive effects to the animals is ensured using Body Condition Score study. Secondly, the method of Duncan was used to assess the strength of preference of the animals towards Metazoa Ludens. Lastly, the effectiveness of this remote interaction with respect to the human users as a interactive gaming system with their pets/friends is examined based on Csikszentmihalyi's Flow theory [1]. Results of both studies inform of positive remote interaction between human user and their pet friends, and the next potential step of advancement for human-animal interaction with advanced interaction technology.

## Author Keywords

human-animal interaction, mixed reality, multimodal interaction, computer gaming, communication.

## ACM Classification Keywords

H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces (D.2.2, H.1.2, I.3.6).

## INTRODUCTION

Human-animal interaction offers many benefits for both the animals and humans [2, 3, 4, 5, 6, 7, 8, 9]. More often than not, the bonding shared between a human and his/her pet is such that the owner is as close to the pet as the owner is to his/her closest family member [10]. On the other hand, digital media interaction has greatly been enhanced by technological advancement. Nonetheless such technologically enhanced interactions are generally restricted to human-human interaction and not extended to promote inter-species interaction.

Despite the lack of technological enhancement to human-animal interaction, the advancement of technology itself is changing the way people live. Although making the life of humanity faster and more efficient, longer working hours

are expected in the professional world in order to match up with the higher level of efficiency (thus produced by technology) [11]. Globalization as advocated by technology has caused an increased in professionals across the globe on business trips [12]. Such huge demands on one's professionalism if left unchecked could result in serious social issues like psychiatric disorders including major depression and alcoholism and health problems like myocardial infarction, diabetes mellitus and hypertension [11, 13]. Furthermore pets are generally neglected and taken for granted by the pets' owners due to this general change in the professional lifestyle [14].

Animals, like human beings, need love and care [2] as well as a good dose of exercise with suitable diet to ensure healthy living [6]. With this negligence the pets will be deprived of the love and care they so required from their human families [2]. The chances of them playing with their human families may be reduced, which may introduce illness related to lack of exercises like obesity, decrease immune response and muscle atrophy [6]. Thus there is a need to create an interface that is capable of allowing humans to shower their pets/friends with attention locally or remotely; in addition the element of exercise may be incorporated into the system to add yet another beneficial feature for the pets. In the current society whereby animals are slaughtered for food eaten not for sustenance but pleasure, where cancerous cells are injected into small furry animals for lab tests, we instead hope to create technology that allows humans to stay in touch and enjoy the animal's company through joint game play. In this manner we aim to promote human-animal interaction and welfare through this interface, it will not only bring benefits to the users but more importantly to the animals as well.

Unbeknownst to most, such negligence of animals may be more detrimental to the humans than their pets. Pets are capable of satisfying human being's need to nurture, providing social support and unconditioned attention and love to their human owners [2], suggesting that they might potentially be able to counteract the negative aspects of the increased pace of the professional lifestyle. Pets are capable of increasing the self-esteem of their owners [3], reduce loneliness [4], stress and anxiety level [5]. They are capable also to provide educational, recreational, motivational and therapeutic benefits to enhance the quality of life [6]. On a physiological health level, human-animal interactions are able to help reduce the level of blood pressure of the humans thereby reducing the risk of hypertension [7]. Interactions with pets are found out also to be beneficial to the cardiovascular conditions of the pets' owners [8] and

bring about a significant reduction in minor health problems [9].

To summarize, one negative aspect of the increased in demands of one's professionalism is the negligence of humans with respect to their interaction with their pets [14]. Not only does this deprive pets of the love they need [2], but with this inattentiveness brings a great number of negative consequences. The positive consequences of increased human-animal interaction could counteract some of the mentioned negative side effects of the fast paced modern world. With respect to all these realizations of the benefits that human-animal interaction can offer, the possibility of extending technologically enhanced interaction to promote human-animal interaction may have great potentials to mend some of the gaps as brought forth by hectic lifestyle of the working professional. By allowing human to interact with pets remotely when direct interaction is not possible (like when they are away for extended business trips), not only will the issue of pet negligence be addressed, the negative social issues caused by hectic professional lifestyle will be addressed as well.

### **Objectives**

In this paper we present a mixed reality based system named *Metazoa Ludens* to match the potentials of remote interaction technology to the challenges of contemporary technologically-aided human-animal interaction design. The aim is to explore the creation of an interface capable of remote human-animal interaction, taking into consideration the different physiological and psychological make-up between humans and their pets, and the way they may interact with the interface. This is so in order to create an effective way for humans to interact with their pets remotely. It is noted that such an interface is meant to enhance human-animal interaction by allowing human to continue interacting with their pets *even* in a remote situation, and *is not* meant to replace conventional human-animal interaction such as touch and hugging. A study to show that *Metazoa Ludens* is beneficial to the hamsters based on Body Condition Scoring study (which is a rapid and accurate scientific method for assessing the health status of small animals including hamsters [15]) will be conducted. In addition a user study of the system based on Csikszentmihalyi's Flow theory [1] will be carried out. These studies are carried out based on strong, dependent theoretical models as mentioned above to show the effectiveness of *Metazoa Ludens* as a digital media for inter-species interaction.

We begin by discussing related works done for both human-animal interaction, remote interaction system and other mixed reality game systems. The design for the system is discussed, followed by a technical description of the system. We evaluate the system both with respect to the animals as well as from the users' point of views. Then the results are presented and discussed and how the results may guide further iterative development of the systems, interface hardware and applications.

## **RELATED WORK**

### **Human-animal interaction system**

Current human-animal interaction between pet owners and their pets mostly involved simple games to the likes of fetch, or chasing squeaky rubber toys. A more established tool-based interaction used for training dogs known as clicker training [16] uses a click sound made just before a treat is given. Nonetheless all these game plays with pets are simple and do not utilize the enriching experience that sophisticated high-tech devices like video game systems (Xbox, Playstation) are capable of giving.

Alternatively technically sophisticated works done on human-animal interaction mostly involve non-living electronic/virtual pets like AIBO [17], Tamagotchis [18] and Furby [19] which have been created to augment the human-animal interaction process by making use of technological devices to give a more enriching experience. Other uses of such robotic pets have been developed like Sekiguchi [20] who introduced a robotic teddy bear for interpersonal communication and Druin [21] who proposed a robot animal that is capable of telling stories to children.

Nonetheless such virtual/robotic pets are not alive, hence lacking in complex behaviors and interactivity (that make live pets so endearing) and thus are not able to live up to the pet-owner's expectations of a pet [19]. Behrens [18] pointed out that unlike real pet when Tamagotchis die they are born again and again (so long as the batteries last) which can be confusing especially for children. This would foster a negative psychology within the children which may eventually negatively affect the society [14].

For the studies done on a group of children owning a Furby, it was found out that when the robotic pet eventually broke and the children realized that it was only a toy, they felt angry at being fooled, betrayed and taken in, having emotionally invested on a machine which they thought was alive [19]. Thereby showing there exist still a difference in perception and expectation between living and robotic pet companions.

In addition even though it was found out that robotic pets like AIBO are capable of providing the elderly with physiological, emotional and cognitive relief, the companionship is still not the same as that shared by human and real pets [22]. While another toy entertainment company has produced a dog language translator device named *Bowlingual* [23]. Nonetheless these devices are non-interactive and are both one-way position information interface. Thus there is a need to create a system that is capable of greatly enhancing the interactivity between animal and human by using advanced technology.

In *Cricket-Controlled Pacman* [24], a human player may play the traditional computer game of Pacman with real live crickets. The crickets play the role of the ghosts and run in a real maze while the human play the role of the pacman and controls pacman on a virtual game screen. Nevertheless

in the real maze the ground vibrates with the aid of motors. This agitates the crickets and causes them to flee. This is done to ensure that the crickets, as ghosts in the game, are constantly moving to “chase after” pacman to allow a more enjoyable game play for the human. A negative motivation (fear from the vibration) is employed throughout the game to the crickets to ensure an enjoyable game play for the human. Metazoa Ludens on the other hand is an interface meant for the benefits of the animals as well as in promotion of human-animal interaction. Positive motivation is employed throughout the game such that the animals perform the game play willingly, and not out of fear or agitation. In addition to that the game play ensures healthy exercise to the animals which are beneficial for the well being of the pets.

#### **Remote interactive system**

As mentioned previously the advancement of the modern world has brought pet owners away from their homes, spending hours at work either in office or overseas business trips away from their pets. This uncovered the need to incorporate remote interactivity into the human-animal interaction system. Related remote interaction systems include Psybench [25], InTouch [26] and Denta Dentata [27]. Such systems describe a bidirectional way for remote interaction; nonetheless these remote interaction systems only take human-human interactions into consideration without consideration of human-animal interactions.

Rover@Home [16] is a system using common Internet communication tools such as webcam, microphones and speakers to allow communication to dogs over the Internet. Nonetheless the system is developed for the purpose of creating autonomous online virtual characters. A need thereby arose to incorporate remote communication technology into a system which allows remote interaction between humans and their pets.

#### **Mixed reality gaming system**

There are many mixed reality games that allow remote/web players to interact with players participating in the game in a more physical and ubiquitous manner. For example Can You See Me Now [28] whereby physical players chase remote avatars of web players, Human Pacman [29] whereby players don the roles of both Pacman and Ghost and play the traditional video game of Pacman in a real physical environment with augmented reality display. Such mixed reality game not only allow remote interaction between players but they open up a new genre of gaming whereby the traditional electronic games are taken out of the computer and players no longer sit in front of the computer to play games [29]. Nevertheless such mixed reality games only address human-human interactions.

Poultry.Internet [30] on the other hand is a mixed reality interactive system developed for remote human-pet (chicken in this case) interactions through the Internet. Pet owners can pat their pet chicken while away in office or business trips through the Internet via a pet jacket which the pet chicken is wearing. This is the first ever known remote

haptic human-animal interaction. Building upon Poultry.Internet, Metazoa Ludens extends and augments this by allowing pet owners to interact with their pets via playing computer games (either locally or remotely) with them.

#### **METAZOA LUDENS – FUNDAMENTAL DESIGN**

With a mixed reality remote interaction gaming system in mind, designs and conceptual outlines are drawn. These result in an iterative development which forms the eventual system design. For better interaction between user and the system, possible user scenarios are given. This is done for a better understanding of the users’ interaction needs, thereby putting that into consideration in the system’s interface design.

#### **Remote interaction**

*Marie finally gets back to her hotel room in Tokyo after a whole day of meeting on her business trip. She turns on her Metazoa Ludens system and immediately she gets connected to her beloved pet hamsters back in her home (thousands of miles away in Los Angeles) and she can carry on playing games with them as if she was back home.*

One of the fundamental objectives of Metazoa Ludens is to allow owners to play with their pets especially from remote locations. This is to ensure owners are still connected to their pets under circumstances where they are physically apart (like business trips). As such, as depicted in the scenario users need to be able to get connected to their pets via Metazoa Ludens easily anywhere in the world. Using existing Internet infrastructure which is widely available around the world, Metazoa Ludens can therefore provides remote connectivity between humans and their pets easily using standard computers.

#### **Pet’s choice**

*It is mid-afternoon and Mandy’s pet, Fluffy, feels it is time to play Metazoa Ludens with Mandy. With that she choses to start the game with Mandy and move into the game play area from her cage.*

One of the most important considerations for Metazoa Ludens is that the hamsters are given a choice to play the game. As depicted in the scenario should the hamster feels that it is time to start the interaction it is able to do so. The interface for the hamster thus should include a way for it to have a choice to play the game. A way for the hamster to interact with the system and communicate that choice is to create a tunnel leading from the cage of the hamster to Metazoa Ludens structure for game play. The hamster is thus able to “select” to play or not to play by simply moving to and fro between the cage and the Metazoa Ludens structure through the tunnel (as its interaction interface).

#### **Pet interface**

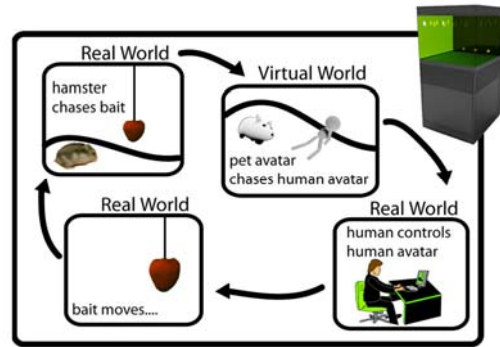
*After one month of using Metazoa Ludens, Billy noticed that his pet hamster is less obese and more active than before. Not only that each time his hamster is more than willing to leave the cage to play Metazoa Ludens with Billy.*

One important concern for Metazoa Ludens is that not only is it beneficial to the humans, it should be beneficial to the pet hamsters as well. Since Metazoa Ludens aims to allow remote game play between humans and their pets, one way to incorporate benefits to the hamsters is through the way the hamsters interact with the system. By making the interaction such that mild exercise is required from the hamsters, the system will thus become beneficial for the hamsters in terms of their health and well being. As regular exercises will prevent the hamsters from being obese and thereby reduces the possibilities of obese related diseases.



**Figure 1. The running wheel, the hamster cage and the running space in Metazoa Ludens.**

Examining possible exercises for hamsters, the idea of using the running wheel (which is most common for hamsters) is discarded since the running wheel is known to cause chronic stress and significant hypertrophy of the heart in hamsters and can result in injuries whenever the hamsters' feet get stuck in the wheel [31]. Running which comes most naturally to the hamsters is thus selected. This suggests that the system ought to have an area set aside for the hamsters to run since the hamsters will be interacting with the system through running. The running area thus becomes the primary interface for the hamsters. Comparing the sizes of the running wheel, the cage and the running area of Metazoa Ludens (see Figure 1), the size of a standardized commercial running wheel is about 105mm in diameter, the size of a standardized commercial cage is generally about 215mm by 270mm while the running area of Metazoa Ludens is 860mm by 860mm. Thus Metazoa Ludens gives a large free running space for the hamsters. The hamsters may also prefer the bigger running area over their smaller cages and running wheels as hamsters are known to love to run around a large area as contrast to the cages where they are normally kept in the house [32].



**Figure 2. System Overview of Metazoa Ludens.**

A source of positive motivation for the hamsters to run will be required such that as depicted in the scenario the hamster has a positive feeling to carry out the game play. Besides having the large running area, a bait could be used to entice the hamsters into running and thereby allowing interaction with the hamsters through the system. As hamsters are known to be gatherers of food (rather than hunters of preys) it is not in their nature to run after food. Instead hamsters are known to be powerful diggers; this is a result of them always digging into the ground to create tunnels which they love [33]. It is the nature of hamsters to explore tunnels as that is where they normally store their food resources in nature [33]. A mechanical arm holding a small tunnel is thus created. This forms the interface which enables the interaction between the hamsters and the system. The tunnel will give a positive motivation for the hamsters to look for in the game play since hamsters generally love to explore tunnels [33]. Hence to connect the humans with the hamsters through the system, control of the mechanical arm is given to the pet owner via the Internet.

#### **SYSTEM DESCRIPTION**

With the system interface design as described above with consideration of the humans and the hamsters' needs. An overview of the overall system is given next, followed by technical details of the system.

#### **System Overview**

As shown in Figure 2, in the real world within the big running space of the system, the hamster chases after a physical movable arm on a moldable surface area. The movement of the hamster is then translated into the movement of a pet avatar in the virtual gaming space which is shared by the human. The human controls the movement of a human avatar in the virtual gaming world, which is actually controlling the movement of the physical bait in the real world. Thus, this loop enables the merging of two realities, both human's reality and the animal's reality, either locally or remotely via Metazoa Ludens system.

Inside the structure a camera is placed at the top for tracking of the pets' movements on a mechanical driven arm that makes up the movable bait. The surface which the pets scamper upon is a highly moldable latex sheet molded

by sixteen actuators (electric motor driven) placed directly beneath them.

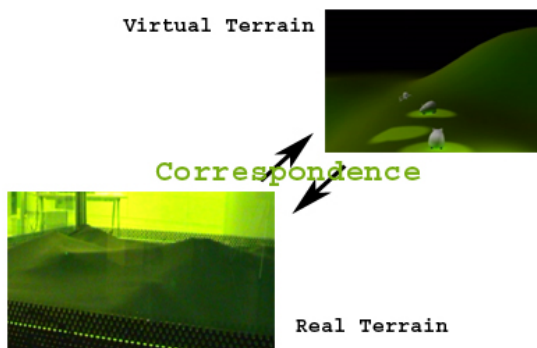
### Camera Tracking

A color video camera is used to translate the movements of the hamsters into the Metazoa Ludens System. This camera is mounted on the same movable arm as the bait and observes an area around the bait from above.

The camera tracking system allows the user to play either with multiple hamsters at one time or just play with the single hamster since the tracking algorithm will always know where which of the pets is. The output of the camera tracking system is a two-dimensional coordinate which shows the position of every hamster inside the field of view of the camera. This coordinate is used to display the 3D representation of the pet in the game.

### Moldable latex surface

A moldable latex sheet is used for the running area's surface. This enables the mechanical actuators below the sheet to be able to mold the shape of the surface in accordance to the virtual terrain of the gaming world in real time (see Figure 3).



**Figure 3. Moldable surface which corresponds to the changing terrain in the virtual world.**

Latex is used as the elasticity and the strength of the material allows it to be stretched while being strong enough to withhold the weight of running hamsters.

### Mechanical arm and actuators

A mechanical XYZ arm capable of x-, y- and z-axes is used to control the movable tunnel. Similarly 16 mechanical actuators are used below the latex surface. Using the same mechanism as described above, the vertical movements of the actuators are thus able to push and pull the latex surface hence creating the real terrain to match the virtual terrain of the virtual gaming world.

### System/Game Engine

The system/game engine is basically made up of 3 layers. Internet layer to handle remote communication via the Internet, stepper motor layer to send signal to the stepper motors to control the actuators and mechanical arm and lastly the game layer in charge of the 3D real-time graphics of the virtual gaming world as well as the game play. The structure will house the Internet layer as well as the stepper

motor layer in a sub-system named the server while the equipment that the owner is using (be it a desktop at home or a laptop in a hotel room) holds the game layer in another sub-system named the client. The basic functioning of these two sub-systems is to facilitate remote communication between the server and the client over the Internet. TCP/IP protocol is used to transmit the data as packets over the Internet.

## EVALUATION, RESULTS & DISCUSSION

### Study 1 – Health benefits to the hamsters

A trial test was carried out to assess the benefits of the system through regular exercise to the hamsters. In assessing the health of small pets like hamsters and maintaining their natural lifespan, it is best to have a common descriptive method among scientists and veterinarian. Body Condition Scoring (BCS) is an accurate and useful tool used for the evaluation of overall health condition of animals like mice and hamsters. Unlike impractical techniques like obtaining body weights and temperatures which can be time-consuming and tedious, BCS techniques are more practical and rapid [15].

Evaluations on individual hamsters are done at least once a week to monitor the hamster closely. The body condition of the hamster is given a score based on a scale of 1 to 5:

- 5: The hamster is obese; its bones cannot be felt at all.
- 4: The hamster is well-fleshed; its bones are barely felt.
- 3: The hamster is in optimal condition; its bones are palpable but not prominent.
- 2: The hamster is getting thinner; its bones are prominent.
- 1: Advanced muscle wasting, fat deposits are gone, bones are very prominent. Euthanasia is mandatory.

As hamsters playing in Metazoa Ludens are given exercises hence it is hypothesized that hamsters playing in Metazoa Ludens will have a BCS of closer to 3 after the duration of the study.

### Subjects

Subjects were hamsters, *Phodopus roborovskii*, belonging to a local group of hamster lovers community whose owners took part in the study (see Study 3) together with their pet hamsters to promote the use of technologically aided human-animal interaction. Subjects were between 1 and 2 years of age and were viral antibody free and parasite free. These were monitored by examining on skin scrapings, fecal flotation samples and anal tape impressions. For uniformity purpose the same diets (seeds) and filtered water were given to the subjects throughout the duration of the study. The cages were allocated in a room with controlled lighting system and optimal temperature and humidity [32].

### Procedure

All hamsters had their BCS taken at the start of the first week of the experiment by three different observers and the mean BCS was taken. BCS was assessed by placing the hamster on a flat surface. The base of the tail was held with

the thumb and index finger of one hand. The scoring of the degree of flash and fat covered was done either by running the little finger of the same hand over the sacroiliac area or by palpating the sacroiliac area with the fingers of the other hand [15].

For 6 weeks, the metabolizable energy requirement (MER) [34] from each hamster was calculated daily and the amount of food they were given each day was in accordance to the MER of each individual hamster. This was to ensure each hamster was given just the right amount of food and to prevent a situation whereby the hamsters were to lose weight due to undernourishment or to become obese due to overfeeding.

The hamsters were allowed to play Metazoa Ludens for an hour each on every weekday for the period of 6 weeks. At the end of the sixth week their mean BCSs were taken

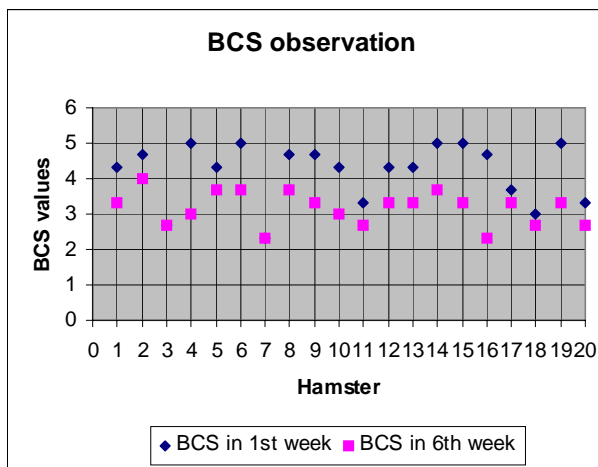


Figure 4. BCS scores of hamsters.

again.

#### Statistical Analysis

To compare ordinal data (discrete scoring of BCS) between two time points, we used the Wilcoxon signed-rank test for paired data. A group size of 20 subjects was used since when the sample size,  $n \geq 15$ ,  $n$  is considered large and the distribution tends to a Normal distribution [35]. All statistical tests were two-tailed, with statistical significance at 0.05. Data are expressed as means unless otherwise specified.

#### Results

Of the 24 hamster owners and their pet hamsters screened, 20 ( $\approx 83\%$ ) subjects were enrolled in the study (3 were not interested, 1 did not return for follow-up). The final study group consisted of 9 female hamsters and 11 male hamsters. Results are shown in Figure 4.

By using Wilcoxon signed-rank test, Metazoa Ludens was found to be able to change the BCS of the subject hamsters over the study period ( $z = -3.8230$ ,  $p = 0.0006$ , Wilcoxon

signed-rank test). Further statistical analysis of the mean BCS of the hamsters in the 6<sup>th</sup> week using Wilcoxon signed-rank test showed that the mean BCS of hamsters after 6 weeks of using Metazoa Ludens tend towards 3 ( $z = -1.4154$ ,  $p = 0.1586$ , Wilcoxon signed-rank test), which is the optimal BCS score for hamsters.

Hence it can be concluded that after 6 weeks of playing with Metazoa Ludens, the hamsters are getting healthier and their body condition tends to optimal.

#### Study 2 – Pets' choice

Besides studying the health benefits of hamsters, a separate study was carried out to measure the motivation of the hamsters to play Metazoa Ludens. Study 2 was carried out after Study 1 as both studies are rather similar and we did not want an interference of results. In this study the method of Duncan [36] was adapted to assess the strength of preference of the hamsters towards Metazoa Ludens.

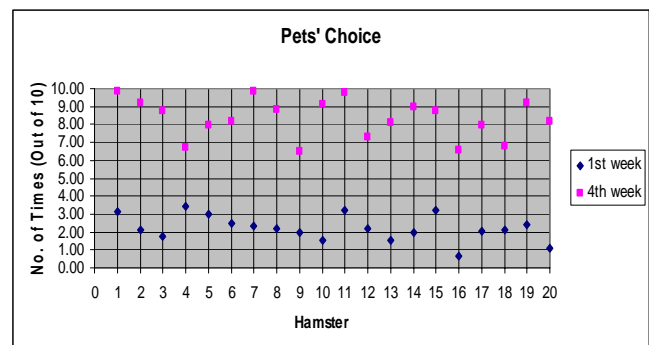
#### Subject

Subjects used were the same subjects used in Study 1 with all experimental conditions remained unchanged.

#### Procedure

All hamsters were placed in their individual cages separated from the Metazoa Ludens structure. For ten times a day each hamster's cage would be linked to the tunnel connecting to Metazoa Ludens (described in Scenario 2 previously). Once the hamster entered the structure through the tunnel the Metazoa Ludens game would be played with the hamster. The number of times taken for the hamsters to enter the Metazoa Ludens structure within 10 minutes of linking the cage to the tunnel was noted.

The study was carried out for 4 weeks and the mean percentage for the number of times each hamster chose to play Metazoa Ludens in the 1<sup>st</sup> week was compared to that in the 4<sup>th</sup> week. Based on the design of the pet interface which is towards the preference of the hamsters (see Scenario 3) we hypothesized that after 4 weeks the mean number of times for the hamsters to enter the tunnel to use Metazoa Ludens will increase, that is the hamsters' preference for Metazoa Ludens will increase.



**Figure 5. Pets' Choice.**

*Statistical Analysis*

Like Study 1, Wilcoxon signed-rank test was used and all other statistical assumptions and conditions remained unchanged unless otherwise stated.

*Results*

The results are given in Figure 5. By using the single-tailed Wilcoxon signed-rank test, it was shown that the mean number of times taken for the hamsters to enter the tunnel per day increased over the study period ( $z = 3.9199$ ,  $p > 1.0000$ , Wilcoxon signed-rank test). With the two-tailed Wilcoxon signed-rank test it was shown that this increase was by 6 times per day out of the 10 possible given chances ( $z = 0.7467$ ,  $p = 1.5468$ , Wilcoxon signed-rank test), that is 60% increment.

As it is shown that the hamsters increasingly initiates playing Metazoa Ludens during the study period, hence we conclude that the hamsters want to play Metazoa Ludens.

**Study 3 – Users' enjoyment based on Flow**

For the users, a user survey was carried out to evaluate Metazoa Ludens system as a game. Game flow of the system was then broken down using features as described by Csikszentmihalyi's Flow theory [1] to evaluate the users' enjoyment of the game. Metazoa Ludens game flow is broken down as follows:

**Concentration:** Concentration on the game is needed and players should be able to concentrate on the game.

**Challenge:** The game should contain challenges that match the players' skill level.

**Player Skills:** Player skill development and mastery should be supported in the game.

**Control:** Player should be able to feel in control of their actions in the game.

**Clear Goals:** Clear defined goals should be given to the players at appropriate times.

**Feedback:** Appropriate feedback from the game at appropriate times is given.

**Immersion:** Players should feel deeply involved in the game and with little/no effort.

**Social Interaction:** The game should support social interaction as well as create opportunities for it.

Element	Criterion	Question
Concentration	- games should quickly grab the player's attention and maintain their focus	1) Did the game grab your attention and maintain your focus?
	- players should not be distracted from tasks that they want / need to concentrate on	2) Can you concentrate on the tasks at hand in the game?
Challenge	- challenges in games must match the player's skill level	3) Does the game skills needed match yours?
	- games should provide different levels of	4) Do you think the game provide different

	challenge for different players	levels of challenge for different players?
	- the level of challenge should increase as the player progresses through the game and increases their skill level	5) As the game progresses does it become more challenging?
Player Skills	- players should be able to start playing the game without reading the manual	6) Are you able to play the game without spending too much time at the instructions?
	- learning the game should not be boring, it should be part of the fun	7) Is learning how to play the game fun?
Control	- players should feel a sense of control over their character or units and their movements and interactions in the game world	8) Do you feel in control of your character in the game?
	- players should feel a sense of control over the game shell (starting, stopping, saving etc.)	9) Do you feel in control of the game shell (starting, stopping, saving etc.)?
Clear Goals	- overriding goals should be clear and presented early	10) Is the objective of the game clear and presented early?
	- intermediate goals should be clear and presented at appropriate times	11) Are intermediate game goals clear and presented at appropriate times?
Feedback	- players should receive feedback on their progress to their goals	12) Do you have a clear picture of your progress to the game goals at any point of time?
	- players should receive immediate feedback on their actions	13) Does the game give you immediate feedback of your actions?
	- players should always know their status or score	14) Do you always know your health points and time remaining?
Immersion	- players should become less aware of their surroundings	15) During gameplay are you less aware of what is happening physically around you?
	- players should experience an altered sense of time	16) Are you aware of the passing time during gameplay?
	- players should feel emotionally involved in the game	17) Do you feel emotionally involved in the game?
Social Interaction	- games should support competition and cooperation between players	18) Do you feel the competition against the pets and other players (if any)?
	- games should support	19) Does the game

	social communities inside and outside the game	support social communities (for both human players and pets) inside and outside the game?
Human-animal interaction	- game should support human-animal interaction	20) Do you feel the presence of the pets during gameplay?
	- game should improve human-pet relationship	21) Do you feel closer to the pets after gameplay?

**Table 1. Questions for the user survey and their corresponding criterion and elements.**

The original set of questions for the Flow model has been created for a generic task (like surfing the Internet) therefore some questions have been modified slightly to adapt to the Metazoa Ludens environment. In addition questions related to human-animal interaction are added as well. Table 1 illustrates the questions and the corresponding criterion and elements in the Flow model.

*Subjects*

Subjects were recruited from a local group of hamster lovers community. There were 20 subjects randomly selected with an average age of 25.4 years old. Gender was 55% male and 45% female. All subjects completed written informed consents before inclusion in the study.

*Procedure*

The survey was conducted on first time users of Metazoa Ludens right after game play. Data collected from the survey are expressed as means and standard deviation unless otherwise specified.

Question No.	Options				
	Yes, very	Yes	Fairly	Not really	No
1	75.0%	25.0%	0.0%	0.0%	0.0%
2	70.0%	10.0%	20.0%	0.0%	0.0%
3	65.0%	20.0%	15.0%	0.0%	0.0%
4	70.0%	30.0%	0.0%	0.0%	0.0%
5	60.0%	20.0%	20.0%	0.0%	0.0%
6	95.0%	5.0%	0.0%	0.0%	0.0%
7	85.0%	15.0%	0.0%	0.0%	0.0%
8	95.0%	5.0%	0.0%	0.0%	0.0%
9	65.0%	20.0%	10.0%	5.0%	0.0%
10	95.0%	5.0%	0.0%	0.0%	0.0%
11	70.0%	5.0%	20.0%	5.0%	0.0%
12	65.0%	15.0%	20.0%	0.0%	0.0%
13	65.0%	15.0%	15.0%	5.0%	0.0%
14	85.0%	5.0%	10.0%	0.0%	0.0%
15	95.0%	5.0%	0.0%	0.0%	0.0%
16	60.0%	15.0%	20.0%	5.0%	0.0%
17	0.0%	0.0%	10.0%	40.0%	50.0%
18	15.0%	70.0%	10.0%	5.0%	0.0%
19	15.0%	55.0%	20.0%	10.0%	0.0%
20	60.0%	10.0%	15.0%	15.0%	0.0%
21	65.0%	30.0%	5.0%	0.0%	0.0%

**Table 2. Results of Survey.**

*Results*

Results of the survey are given in Table 2. Of the 9 elements explored with this survey, all of them performed positively in the survey as for all questions posed more than 50% selected the favorable choice to the questions posed. Nevertheless it is noted that amongst the 9 elements, Immersion and Social Interaction did not score as well as the rest.

For Immersion, majority agreed that they feel immersed in the game instead of feeling “greatly” immersed in the game. However considering that the players answered the surveyed only after their first try at the game, the result obtained may therefore be considered a positive result. Immersion may be improved by the use of more captivating music and sound effects which signifies real-time events of the game to capture the users’ attentions.

For Social Interaction, majority agreed that they do feel the presence of social interaction at work instead of feeling “greatly” the presence of social interaction. However considering that the players are new to the game and having to cope with getting use to the controls and the game play in

real-time, having felt the presence of social interaction instead of feeling “greatly” for it should be considered a positive result. A possible way to improve Social Interaction further would be to include chat feature which will then allow players over the Internet to communicate with each other.

Generally it can be concluded from the above results that the 9 elements of Metazoa Ludens are effectively implemented. Although there is still some room for improvement in certain features of the system, it can be concluded that Metazoa Ludens is effective as an entertainment system for leisure and human-animal interaction.

## CONCLUSION

The apparent implication for this work would be a novel way for humans to interact with animals through computer game-play. It is expected that the work of this project shall kick start an entire new field for both animals and humans.

Contrasting human-human interaction with human-animal interaction, the latter would prove more unique in a sense that animals and humans do not speak the same language and hence animals will not be able to respond to human linguistic expressions. This would increase the challenges in researching into a system for inter-species computer interaction since the system would be more limited in terms of the number of dimensions available where multi-modal interaction is concerned.

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