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# NEAT-o-Games: Ubiquitous Computing Meets Exertion Interfaces

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## **Abstract**

Exertional Interfaces are often assumed mean volitional expenditure of large amounts of energy over short periods of time. However, they can also involve the expenditure of lower amounts of energy over much longer periods. The role of **Non-Exercise Activity Thermogenesis (NEAT)** has become a key component of obesity research, prevention, and treatment. This paper describes research that aims to suppress the obesity epidemic by infusing NEAT in the sedentary lifestyle of an average person. The method combines unobtrusive physiologic sensing, novel **Human-Computer Interaction (HCI)** technologies and multi-user gaming. It supports a strong motivational framework based on ubiquitous computer gaming, appealing enough to likely change the behavior of 'couch potatoes' on their own volition. This novel generation of computer games (**NEAT-o-games**) is fueled by activity data recorded by small wearable sensors. Data from the sensors are logged wirelessly to a **Personal Digital Assistant/Cell Phone (PDA)**, which acts as the central computing unit of the system. Algorithmic software processes these data and computes the energy expenditure of the user in real-time. This paper presents a prototype implementation of NEAT-o-games and initial evaluation data.

### Keywords

Computer game, energy expenditure, ubiquitous computing

### ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

### Introduction

The importance of obesity to world health is without question. There are 1 billion people in the world who are overweight and 300 million with obesity. Recent work suggests that this is driven by a reduction in energy expenditure, rather than a rise in energy intake. In Britain where obesity has doubled since the 1980's, energy intake appears to have decreased.

**Non-Exercise Activity Thermogenesis (NEAT)** is the energy expenditure of all physical activities other than volitional sporting-like exercise. NEAT is highly variable among individuals. NEAT in an agricultural job exceeds that for an office job by 1,500 kcal/day. Similarly, an evening of television watching expends 30 kcal whereas an evening of gardening and walking the dog expends 600 kcal. This marked variability in NEAT supports the notion that is fundamental in energy balance [2].

Computer gaming has been proposed as a way to increase activity to fight obesity [1]. The ultimate goal of this research is to increase NEAT in the modern lifestyle. It leverages already ubiquitous gadgets (e.g., cell phones), unobtrusive metabolic measurement technology, and the entertainment appeal of computer gaming by developing a new breed of computer games catalyzed by human motion (**NEAT-o-games**).

### Methodology

We use a tri-axle accelerometer to measure physical activity. The form factor of the sensor is similar to a mobile phone and is attached to the waist of the user. It communicates with a PDA through a Bluetooth connection (**figure 1**). Measurements are recorded every second and are correlates of the energy expended by the user due to motion at the time. These expenditure data are being used in novel computer games that require physical activity. We are developing a new generation of ubiquitous games where characters are being moved by activity data logged in by body-worn sensors (NEAT-o-games).



**figure 1.** User wears activity sensor at his waist and holds a Palm Treo PDA at his palm. The devices are indexed in the right panel, where the form factors are evident.

In this paper, we report the first NEAT-o-game that can be played either between many people participating in a buddy list or between a single person and multiple computer-generated opponents. Every user is

represented in the game as an avatar that runs around a circuit. Each avatar's motion is controlled by the accelerometer data logged in from the waist sensor of the user. The most physically active user is ahead in the race. Data communication between the users' PDAs participating in this competitive race is effected either through the cellular broadband or Wi-Fi. Players in the game are notified periodically of their standing and a winner is proclaimed every day. Two sample screens are shown in **figure 2**.



**figure 2.** The left screen shows a two-player NEAT-o race. In this, the two avatars race around the track and overall standing is shown on the left. The rate of animation is based on the level of user physical activity. The right screen shows a congratulatory screen for an individual who is doing well. It shows graphically in a dial the relative activity lead and a pleased action figure.

### Evaluation

We ran an initial evaluation with 4 users. They used the system in three settings: 1) with the motivational interface off, 2) playing against a computer-generated opponent, and 3) playing against a human opponent, up to 15 miles away. Energy expenditure against a human opponent was highest. Expenditure versus the computer opponent was lower than against the human opponent, but still markedly above baseline. User

feedback was very positive and users felt NEAT-o-gaming would be helpful in a weight-loss program.

### Conclusions

Although quite preliminary, this prototype demonstrates both the feasibility and acceptability of the NEAT-o-games concept. Initial experiments with a small user set confirmed the robustness of the system operation even when users who played the game were physically miles apart. It also gave a first confirmation of the basic hypothesis: typical sedentary users enthusiastically embraced the game and played it with zest, much the same way one would expect them to play most other competitive computer games. Of course, due to the nature of the game, the side effect was higher physical activity. Feedback from the users was uniformly positive.

**This is the beginning of a long term project between the medical team that established the importance of NEAT, a computing team with interest in cool gadgets and ubiquity, and a usability team with interest in health applications. The three teams have a long history of interdisciplinary cooperation.**

### Citations

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