An Interactive Tool for Creating Multi-Agent Systems and Interactive Agent-based Games (Demonstration)

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ABSTRACT
Utilizing principles from parallel and distributed processing combined with inspiration from modular robotics, we developed the modular interactive tiles. As an educational tool, the modular interactive tiles facilitate the learning of multi-agent systems and interactive agent-based games. The modular and physical property of the tiles provides students with hands-on experience in exploring the theoretical aspects underlying multi-agent systems which often appear as challenging to students. By changing the representation of the cognitive challenging aspects of multi-agent systems education to a physical (hands-on) one, the challenge may become much easier and fun to face for the students.

Categories and Subject Descriptors
I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems – *games.*

General Terms
Human Factors.

Keywords
Human-robot/agent interaction, Development environments.

1. INTRODUCTION
For the distributed processing education as needed for students to learn about multi-agent systems, swarm intelligence, agent based gaming, etc. we suggest using *interactive* parallel and distributed processing that allows the student to easily represent, interact with and create their own agent system in a physical manner. The approach allows students and researchers in a physical, hands-on manner to face sub-problems including distribution, master dependency, software behavioural models, adaptive interactivity, feedback, connectivity, topology, island modeling, and user interaction. As an example, the approach allows experimenting with hierarchical and functional decomposition of problems. An educational tool for this kind of algorithmics learning should allow students to learn about when to utilise shared variables and distributed variables, when to use a scheduler, how to use semaphores for critical sections, and about the issues related to topology, communication, event based control, deadlock prevention, data transfer, etc. *AI* also demands learning about distributed systems for learning about neural networks, artificial life, evolutionary computation, multi-agent systems, swarms, etc.

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2. CHANGING REPRESENTATION
A number of these computer science themes which are necessary to understand for creating multi-agent systems can appear quite abstract to the engineering and computer science student. There is clearly a need to have an educational tool that allows the students to confront these themes in a very concrete manner. We suggest that the best way to learn about these abstract issues is through direct *hands-on problem solving*, following the pedagogical principles of Piaget known as constructionism [2] combined with a contextualised IT training approach for students by allowing them to work with building blocks. Many experiments have indicated that the hands-on, problem-solving, constructionism approach allow the learner to confront abstract, cognitive problem solving in a simpler manner through the physical representation. Different representations (e.g. physical representation) can cause dramatically different cognitive behaviour. Zhang and Norman [3] propose a theoretical framework in which internal representations and external representations form a "distributed representational space" that represents the abstract structures and properties of the task in "abstract task space" (p. 90). They developed this framework to support rigorous and formal analysis of distributed cognitive tasks and to assist their investigations of "representational effects [in which] different isomorphic representations of a common formal structure can cause dramatically different cognitive behaviours" (p. 88).

The physical parallel and distributed system that we present here enables the experience of physically manipulating objects and the material representations of information. The mapping between the physical affordances of the objects with the digital components (different kinds of output and feedback) is a design and technological challenge, since the physical properties of the objects serve as both representations and controls for their digital counterparts. Here, we make the digital information directly manipulatable, perceptible and accessible through our senses by physically embodying it. While playing with the system, the user can take advantage of the distinct perceptual qualities of the system and this makes the interaction tangible, lightweight, natural and engaging. Interacting with a physical parallel and distributed system may mean jumping over, pushing, assembling, touching physical agents and experiment a dialogue with the agents in a very direct and non-mediated way, and hence it is viewed as highly suitable e.g. for student training.

3. MODULAR INTERACTIVE TILES
The Modular Interactive Tiles System (MITS) is proposed as a tool for MAS education. The system is based on physical modules representing agents: Each module has a physical expression and is

able to process and communicate with its surrounding environment. The communication with the surrounding environment is through communication to neighbouring modules and/or through sensing or actuation. A modular system is constructed from many such modules. As a physical multi-agent system, each module works as an agent with a primitive behaviour, and the overall behaviour of the system emerges from the coordination of a number of physical modules (agents), and the single/multi user-interaction. The modular interactive tiles attach to each other to form the overall system. The tiles are designed to be flexible and in a motivating way to provide immediate feedback based on the users' physical interaction, following design principles for modular playware [1]. Each modular interactive tile has a quadratic shape measuring 300mm*300mm*33mm – see Fig. 1. Each module includes an ATmega 1280 as the main processor, four IR transceivers for communication to neighboring modules, a force sensitive resistor (FSR sensor) to measure the force exerted on top of the module, a 2 axis accelerometer to detect horizontal or vertical placement of the module, and eight RGB light emitting diodes with equal spacing in between each other on a circle. Each side of a module is made as a jigsaw puzzle pattern to provide opportunities for the modules to attach to each other. The cover of the modules is made from two transparent satinice plates with a sticker in between. The modular interactive tiles are individually battery powered and rechargeable with a Li-Io polymer battery. A fully charged modular interactive tile can run continuously for approximately 30 hours and takes 3 hours to recharge.

Figure 1. Modular tiles used for feet or hands interaction.

An XBee radio communication chip can be mounted in each tile. Hence, there can be two types of tiles, those with a radio communication chip (*master tiles*) and those without (*slave tiles*). The master tile may communicate with the game selector box and initiates the games on the built platform. If communication is needed e.g. to the game selector box, a PC or another remote tiles platform, a platform has to have at least one master tile.

With these specifications, a system composed of modular interactive tiles is a fully distributed system, where each module (i.e. agent) contains processing (ATmega 1280), own energy source (Li-Io polymer battery), sensors (FSR sensor and 2-axis accelerometer), effectors (8 colour LEDs), and communication (IR transceivers, and possibly XBee radio chip). In this respect, each tile is a self-contained agent and can run autonomously. As a multi-agent system, the overall behavior of the system composed of such individual tiles (agents) is however a result of the assembly and coordination of all the tiles (agents).

The modular interactive tiles can easily be set up on the floor or wall within one minute. The modular interactive tiles can simply attach to each other as a jigsaw puzzle, and there are no wires. The modular interactive tiles can be put together in groups (i.e.: tiles islands), and the groups of tiles may communicate with each other wireless (radio). For instance, a game may be running distributed on a group of tiles on the floor and a group of tiles on the wall, demanding the user to interact physically with both the floor and the wall.

We have implemented more than 30 different games on the modular interactive tiles system, and students can easily implement and test different agent-based games on the system, e.g. on sets of 5-10 tiles. The games include rehabilitation games for cardiac patients and stroke patients, prevention games for elderly, sports games (e.g. used during FIFA World Cup 2010 in South Africa with teleplay to Europe and Asia), music games, brain training games, autism therapy games, entertainment games, etc. (see [4] incl. videos). For making the agent-based games, the students can work on fundamental challenges underlying multi-agent systems including robustness, communication, system connection, token-passing, deadlock prevention, parallelism, reconfiguration, memory sharing, and topology. The MITS model is ideal for implementing all of the above challenges since the hardware components are minimalistic and the distributed system complexity can be developed and tested in a quick and easy manner (Figure 2).

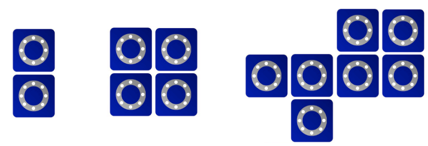

Figure 2. Different topologies of modular tiles.

The simple game *Final Countdown* can work as an example of a simple agent-based game. In the *Final Countdown,* the tiles platform can vary both in aspect and size, since each tile is an agent that behaves like all the other agents in the system. The system consists of a number of agents (tiles) that, when the game is initiated, have all their eight LEDs turned ON. With a given interval (e.g. one second), each agent (tile) starts to "fade-out" switching OFF one LED after the other in a clockwise sequence. If one of the agents gets completely OFF (i.e. zero LEDs turned ON), that agent broadcasts a "game over" signal to the neighbours, which relays this signal, and all agents (tiles) show that the game is over. To restore a single agent (tile) to the initial state of all lights on, the user has to step on it. For the user(s), the game becomes to keep all the agents (tiles) alive by stepping on them. The larger the platform is the more important becomes the strategy users bring into play to keep the game alive, e.g. a multi-user cooperative strategy. Other agent-based games include, for instance, a physically interactive form of Conway's *Game of Life*, and a *color-mix* game, where colours are flooding to neighbouring agents and the agent colour is a mix of colours from neighbours.

4. REFERENCES

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