Playware
- Intelligent technology for children's play

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Introduction
The last decades have seen considerable changes in children's and youth's play with entirely new kinds of play equipments such as computer games and intelligent toys. At the same time we have seen a decrease in outdoor play, street play and the like, which in childhood research is often conceived as an outcome of the marketing of electronic and digital products that are more attractive and compelling to children than traditional play opportunities. A long list of researchers have warned that the penetration of electronic and digital media will harm children's play and even destroy their ability to engage in social and fantasy play [1, 2]. In recent years a growing problem concerning childhood obesity has alerted the industrialized societies and intensified the criticism of children's media and computer usage from health care and medical science. While the lack of physical activity in play is not the only cause behind the rapid growth of obesity among children and youth it is certainly one of the reasons to the problem. Children are spending an increasing amount of their leisure time sitting in front of a screen, and it seems obvious to lay blame on the seductive forces [3, 4] that apparently are embodied in the media and intelligent products. However, in the following we take the liberty to view the matter in a different perspective and to argue that digital, intelligent technology should be seen as a part of the solution rather than only as a problem. On the one hand, the recent developments in mobile and ambient technologies hold promise for play environments that can stimulate children and youth to engage in social and physical play and thus become an important factor in, for instance, the community's fight against an increasing child obesity problem. On the other hand, it can be argued that the belief of a simple cause and effect relation between the increase in new kinds of play equipments and the changing play behaviour of children is neglecting the many significant social, cultural, and physical transformations taking place in modern societies.

The transformations mentioned above have decisive influence on the decrease in traditional play activities among children and youth, mainly because they have deprived them of many opportunities and places that formerly constituted play spaces, not least spaces for physical play. Therefore, the idea that we can turn the wheel back and recreate children's play behaviour from the past, which is the underlying assumption in most childhood research, is a well-intentioned but probably unachievable goal.

"Playware" – a definition
It is not without reason that products that can inspire and create play and playful experiences among children and youth have grown into an important and prospering new industry over the last decades. Computer games are outstanding examples and to day by far the most successful. But the possibilities of using intelligent technology to create play are enormous, and until now only briefly explored and developed. Below we will describe a prototype that can serve as an example of what we consider a new brand of leisure products based on digital and intelligent technology. We suggest the term "playware" as this use of technology to create the kind of leisure activities we normally label play, i.e. intelligent hard- and software that aims at producing play and playful experiences among users and of which e.g. computer games are a sub-genre. Further, we suggest the term "ambient playware" for playware with ambient intelligence characteristics. Ambient intelligence has been defined as the integration of technology into our environment, so that people can freely and interactively utilize it. In concrete terms, ambient intelligence is provided by a large number of small, intelligent devices, ´in-built´ into our surroundings. These devices have three important characteristics: they can be personalized, they are adaptive and they are anticipatory.

It is our belief that such playware and ambient playware hold great potential for the development of a prospering future industry. But maybe even more important than the economic and scientific impact is the potential impact on fighting the above mentioned increasing obesity threat to our population, as the playware can be directly focused on creating new spaces and possibilities for physical activating play, and thereby promote physical health and thus contribute to the reduction of health problems such as obesity and other lifestyle-related diseases, which are of increasing concern in all industrialized societies. In contrast to the vast majority of research into childhood, health and media, we believe that at least part of these problems in the industrialized societies should be dealt with not by fighting electronic and digital media and play equipment but by releasing their potentials.

It should be emphasized that the area of health problems is only one example of the possibilities hidden in playware. These problems are, however, of substantial social significance. In the USA, according to Hedley et al. [5], among adults aged at least 20 years in 1999-2002, 65.1% were overweight or obese, 30.4% were obese, and 4.9% were extremely obese. Among children aged 6 through 19 years in 1999-2002, 31.0% were at risk for overweight or overweight and 16.0% were overweight. According to a study of costs attributed to both overweight and obesity, medical expenses accounted for 9.1 % of total U.S. medical expenditures in 1998 and may have reached as high as $78.5 billion [6]. Also, at the moment, most Northern European countries have 15-20% overweight children, and most Southern European countries have 30-36% overweight children in the age 7-11 years using the cut-off points recommended by the International Obesity TaskForce [7, 8]. In order to fight this threat, as a society we need to not only provide remedies such as new drugs and surgical possibilities, but also preventive actions such as change of diet and sports habits. With playware and ambient playware, we provide a further focus on play and play spaces for physically activating the population as a preventive action. Playware that can initiate physical play should off course not be seen as the only or the ultimate solution, but we regard the concept as hugely important for the society to prevent the growing obesity threat to the society.

Figure 1. Physical activity with playware.

The need for playware

There is clearly a market potential for playware, not only because of new possibilities created by technology, but also, and perhaps most, because there is a growing need for products that can inspire play. As mentioned in the introduction attention is often drawn to the huge increase in the use of the media [9], but a very important causal factor is the changes that have occurred in recent decades in childhood. Not only are children deprived of play spaces, but compared to earlier generations of children there is today a lack of inspiration for play from their peers. One of the decisive changes in children's and youth' social lives in Western societies are that they interact less with children of other age groups [10]. This means that younger children have fewer opportunities to derive inspiration for their games and play from older children, who are "masters of play" [11], and this in itself can explain a great deal of the increase in the use of interactive media, in that children today are much more dependent on playware such as toys and media to inspire and initiate their play. While children traditionally learned the rules of games and how to play from other and often older children while participating in the play culture for instance on the street or in back yards, the rules must now to a much higher degree be embodied in the toys and other play equipments, or learned from watching television cartoons [12]. Here computer games are the best example as they are among other things characterized by having the game rules materialized in the software. In contrast to street games and most board games where the player has to know the rules before being able to play, it is possible to learn the rules of computer games while playing. It can even be an important part of the game itself to figure out the rules. This is not to say that there is no need for other children to learn from, but there is less need for the masters of play, who were an indispensable part of the play culture in the past, and this is a main reason for the success of computer games among children and youth.

Research into children and interactive media has shown that computer games, including the most popular ones, can be regarded as tools for the initiation of play and playing activities in social settings [12, 13]. It should be one of the goals of playware development to utilize motivating and activating elements from computer games in the development of new play equipment and new types of play environments that encourage children to engage in physical activity. The development of ubiquitous, pervasive and mobile computing makes it possible to build new play environments, which contain intelligent technology that can create play and games in the same way as computers contain technology that can create computer games. In the following we describe a prototype of such a play environment. We focus mainly on technology, but the prototype is a result of close collaboration between technologists, play researchers and designers. Indeed, the playware area of research is cross-disciplinary in its point of departure and combines research from different and normally separated areas. The development of successful play products requires research into IT technology, modern artificial intelligence, children's play and learning, children's use of play equipment and design. Our studies presented below show the potential of creating playware by combining play, story telling, modern artificial intelligence, robotics, and design.

Playware technology

In order to support playware and play environment, it is vital to design and develop units that can be distributed in the environment that the users inhabit (e.g. playgrounds, school yards, city squares, skateboard ramps, sports centres). The units to be developed can be considered *building blocks* with processing and communication capabilities. These units are placed in the real, physical environment and utilise the characteristics of the real world to emerge as a collective, intelligent 'robotic' system.

We developed a set of tangible tiles for physically activating children in their play. The tangible tiles are initially utilised in 2D on the ground, but are also extended with wireless handheld units in order to develop activities where children can interact with virtual and/or physical elements in 3D. The new wireless technologies have great potential for the development of new products within the genre of play and games, but exploitation of that potential requires the development of an easily accessible technical platform that joins together the technologies and makes the products widely usable for both producers and users.

The tangible tiles are new play elements, which functions as building blocks by containing processing power, sensors, actuators, and communication capabilities. The tangible tiles have a soft surface, and each measures 40cm*40cm in the first implementation (and 25cm*25cm in the second version). Inside each tile, there is a force sensitive resistor that can register when someone jumps on the tile. The actuation consists of 9 red LEDs and 9 blue LEDs distributed equally on the tile in a 3 times 3 matrix. Furthermore, on the back of the tile, there is made room for a microcontroller (ATmega128) that can register activity from the sensor and control all the 18 LEDS individually. With this simple tile, it is possible e.g. to switch from blue to red or from red to blue every time someone jumps the tile.

Figure 2. Left: the performance tile design. Right: three kids of 5 years of age playing around on a set-up with the performance tiles.

To be able to do more complex games than just switching colors on a single tile, there is communication between the tiles. Hence, the micro controller in each tile can be used to communicate with the four neighboring tiles, and it can control the games. So there is distributed processing and it gives the possibility of using different physical configurations (e.g. different number of tiles and different placements) without having to change any program. Each tile can check if it has a neighbor in each of its four sides.

In this way, we can view the tiles as individual building blocks that each contain processing, sensing, actuation and communication. This is similar to the way of constructing building blocks at a small scale in LEGO blocks, called I-BLOCKS, used for edutainment and cognitive rehabilitation [15] and the way of constructing building blocks for self-reconfigurable robots [16]. In all cases, like with the tangible tiles presented here, each building block has processing, sensing, actuation, and communication, and different physical configurations of the building blocks will result in different overall behaviours of the system.

The control systems provide a close loop between environmental stimuli from users and actuation in the environment, and are achieved through the use of primitive behaviours in the tiles executed in parallel and coordinated to provide the overall behaviour of the playware system. So, the overall behaviour of the system becomes the emergent effect of the interaction with the environment (the users) and the coordination of the primitive behaviours.

As a novel approach to behaviour-based systems, we suggest expanding the more classical view (e.g. [14]) to include not only the coordination of primitive behaviours in terms of control units, but also include coordination of behaviours in terms of physical control units (i.e. building blocks in the shape of the tangible tiles). We can imagine a physical module such as a tile being a primitive behaviour. Thereby, the physical organisation of primitive behaviours (together with the interaction with the environment) decides the overall behaviour of the system. We term this the *behaviour block concept*. In this concept, the overall behaviour of the artefact emerges from the coordination of a number of physical building blocks that each represents a primitive behaviour.

Tangible Games

The tiles can be viewed as the technological platform that provides us with opportunities for creating new kinds of play and games. It is possible to have more than one game in the microcontroller so the users can play different types of games. Hence the tangible tiles are an example of playware, and if implementations make them adaptive, personalised, and anticipatory, we would view them as an example of ambient playware.

We implemented different games on the tangible tiles and analysed children's physical play on the tiles in continuous use for 2 months at a school in Denmark (Tingager Skolen, Denmark). In one of the games, colour race, children compete against each other (more children can play in groups) by first choosing a colour (either blue or red) and then in a hurry jump on the tiles so they turn into their colour. Another example is a tangible version of the computer game Pong where a red arrow moves around randomly and when it gets to one side of the tiles configuration, a child has to step on the tile quickly, to return the arrow to the opponent. The arrow can move to one of the connected neighbours. The wicked witch game is an extension, which uses PDAs and WiFi localization to provide story lines and guidance for the children's play.

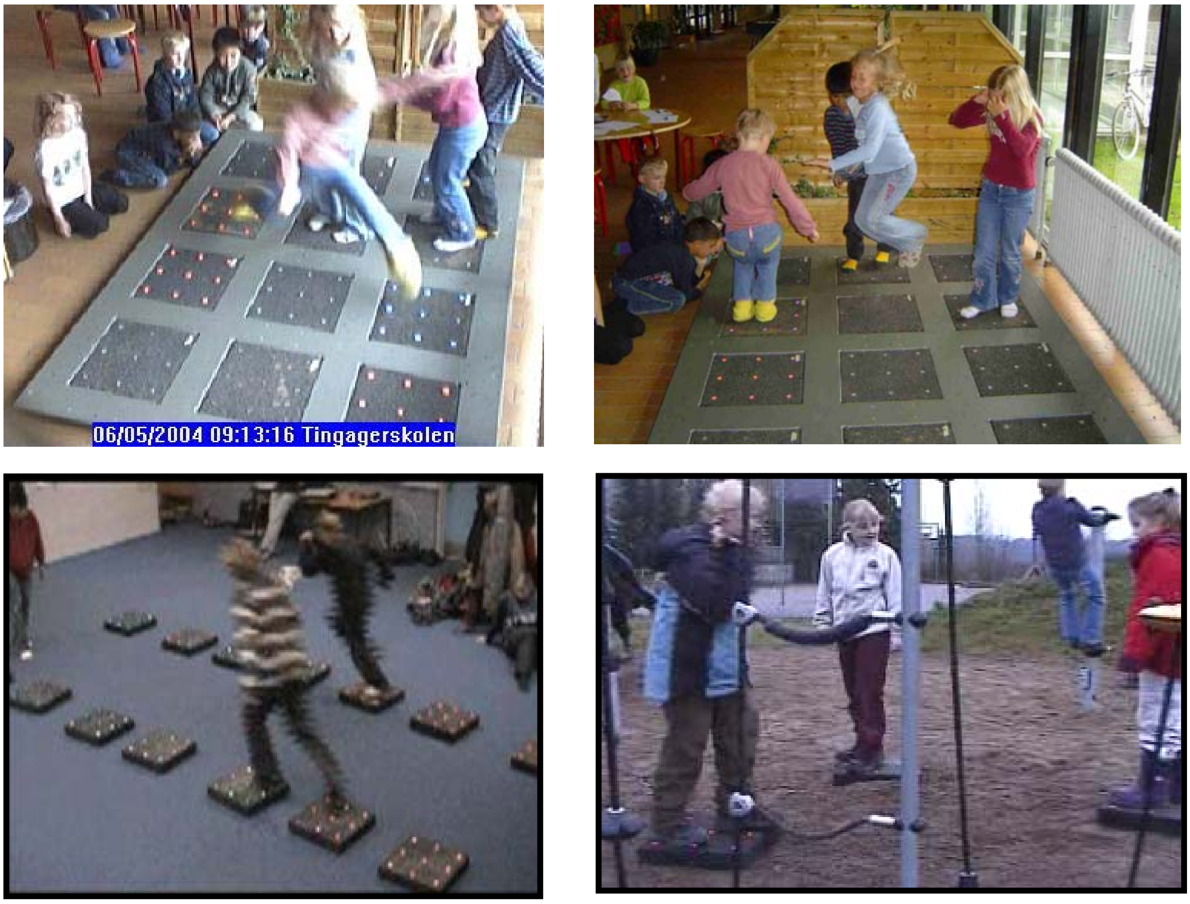

Figure 3. Top: 6 years old children playing on the tangible tiles in a fixed, 3*4 configuration at the Tingager School in Denmark. Bottom: Children playing on the tangible tiles in different configurations indoor and outdoor.

Our goal with the prototype was to investigate whether children would accept the tiles as play equipment and whether these very simple tangible games actually would initiate physical and social play. We observed children playing indoor and outdoor on the tangible tiles and on ordinary playgrounds to investigate play and games activities. Children's interaction with the tangible tiles was continuously video recorded and analyzed over the 2 months period in the Danish school.

It is well known in play research that novel toys and play equipments will trigger children's interest just because they are new, but often children loose interest after a short while [17, 18]. This did not happen with the tangible tiles in the school during the two month period. Not only did we observe that the children accepted the games, but they continued to play during the period of observation. We regard this as an initial success to build on in further development.

Further development

In the light of the observations, we identified four play areas that are useful as a basis for the design of games for playware. The four areas are central aspects and elements in the way children approach the playground equipments, and children often use them simultaneously. Therefore, our categorization of the play areas is not discrete. But we find it necessary to divide play into these areas to make a more operational approach to the term of play: 1) performance, 2) initiation of games, 3) inspiration to "new games", and 4) games with game play.

In connection with the use of digital games, such as computer games, the rules can be discovered and learned, while the player is trying out the game. This can be a part of the playing activity, which is most obvious with computer games. Game play is both practical and theoretical a central subject in relationship with computer games, where inspiration can be collected for development of games with game play. Known computer games can work as a foundation for the development of games for physical play spaces. In this case the interesting part is that this is a new way of thinking about physical games, which place us in front of new challenges. One of these challenges is that it is not always possible to transfer game play from certain computer games to physical play.

In our point of view, successful playware must support these for categories of play. Therefore, the second generation of tangible tiles supports performance acts, initiation of games, new games and game play. Especially we find it important to provide continuous, analogue input and output possibilities, and some story telling facilities by expanding with wireless technology for units used in 3D. Indeed, analogue sensing and actuating capabilities are critical important for the study and promotion of *performance in play*, which constitutes a meeting point of play, creativity and aesthetics. Often performance is noticed as an extra dimension of a play activity (a shout, a sound effect, a bodily act, etc.), but in fact it often becomes the most important activity of the play in itself, and it becomes the one admired and imitated by others. Hence, much of the social gathering around play may be connected with the performance activity. Often the body is the most important instrument in these activities, but also the surroundings can be incorporated and used, such as when children are stumping or shouting in a tunnel to use the feedback from the walls as the echo to make special sound effects, or when a group children use a specific surface, e.g. a rocking plank or branch to make special jumping and swinging movements. Therefore, development is focused on the surrounding and tools that may enhance the children's possibilities in making performance activities in their play. It should be mentioned that the performance aspects are absent in nearly all cases of so-called "intelligent toys" on the toy market of today.

Investigations into performance are, however, just the first step to provide a qualified basis upon which the development of playware can move towards new building blocks and interaction spaces in 2 ½ D and 3 D. This may demand the utilisation of radically new design in terms of form, material, and electronic hardware. For instance, it may be possible to create forms that can match each other and naturally be moved around in the space in order to create different play opportunities based upon the physical reconfiguration, or materials that suggest specific neighbourhood. Building upon the concept of building blocks, processing can be distributed and communication can happen wired or wireless, i.e. by integrating different wireless technologies (e.g. RFID, WiFi, UMTS, Bluetooth and GSM) in the playware. Our first investigations in this direction shows the use of WiFi and the Ekahau system for 3D localisation on Windows CE PDAs communicating with other physical playware elements, and hence mix the virtual representations on the PDAs with the physical play on the physical playware elements.

The characteristics of having building blocks with sensing, processing, actuation and communication capabilities allow us to develop the physical play in interaction with units that can *adapt* and *learn*. Therefore, ambient playware development aims at creating an ambient intelligence environment for physical play by investigating different issues from modern artificial intelligence (e.g. [19]) such as adaptability and learning and applies them to the physical interaction in the interaction space. For instance, adaptation and learning may be utilized for the system to reconfigure processing (e.g. games) based on the physical rearrangement of building blocks performed by the user in the interaction space. On longer term, the ambient intelligence solutions should be developed at different scales, from objects to environments, able to sustain various human activities. These solutions are based on intelligent building blocks that allow non-expert users to develop intelligent interactive artefacts and environments.

References

1. Postman, N. "The Disappearance of Childhood". London: Allen 1983
2. Kline, S. "Out of the Garden: Toys and Children's Culture in the Age of Marketing". Verso, 1993
3. Turkle, S. "The Second Self: Computers and the Human Spirit". New York: Simon and Schuster, 1984
4. Lindstrom, M. and Seybold, P.B. "BRANDchild: Insights into the Minds of Today's Global Kids: Understanding Their Relationship with Brands". Kogan Page, 1994
5. Hedley, A.A., Ogden, C.L., Johnson, C.L., Carroll, M.D., Curtin, L.R., Flegal, K.M. "Overweight and obesity among US children, adolescents, and adults, 1999-2002." *JAMA 291:2847-50*. 2004.
6. Finkelstein, E.A., Fiebelkorn, I.C., Wang, G. "National medical spending attributable to overweight and obesity: How much, and who's paying?" *Health Affairs 2003;W3;219–226*. 2003.
7. Lobstein, T. and Frelut, M.-L. "Prevalence of overweight among children in Europe", *Obesity reviews, 4, 195–200,* 2003.
8. "Obesity in Europe – The Case For Action", International Obesity Task Force & European Association for the Study of Obesity, 2003.
9. Vandewater, E.A., Shim, M., and Caplovitz, A.G. "Linking obesity and activity level with children's television and video game use". *Journal of Adolescence, Vol. 27, pp. 71-85*, 2004.
10. Sutton-Smith, B. "Toys as Culture". N.Y. 1986.
11. Mouritsen, F. "Child Culture - Play Culture". Working Paper no. 2. Department of Contemporary Cultural Studies. Odense 1998.
12. Jessen, C. and Nielsen, C.B. "The changing face and children's play culture. Children's play, learning and communication in a technology driven world". LEGO Learning Institute. November 2003.
13. Salen, K. and Zimmerman, E. "Rules of Play". Game Design Fundamentals. MIT Press, 2000.
14. Brooks, R. A. "A robust layered control system for a mobile robot" *IEEE Journal of Robotics and Automation, 2(1):14-23,* 1986.
15. Lund, H. H. and Marti, P. "Physical and Conceptual Constructions in Advanced Learning Environments", *Interaction Studies 5:2, 269-299*, 2004.
16. Jorgensen, M. W., Østergaard, E. H., and Lund, H. H. "Modular ATRON: Modules for a self-reconfigurable robot" In Proceedings of IEEE/RSJ International Conference on Robots and Systems, (IROS'04), 2068-2073, IEEE Press, 2004.
17. Jessen, C. "Børn, leg og computerspil" (In Danish), Odense University Press, 2001.
18. Lund, H. H., and Nielsen, J. "An Edutainment Robotics Survey" In K. Murase and T. Asakura (eds.) *Dynamic Systems Approach for Embodiment and Sociality*, International Series on Advanced intelligence, vol. 6, 173-205, Advanced Knowledge International, 2003.
19. Pfeifer, R. and Scheier, C. "Understanding Intelligence", MIT Press, MA, 2001.