A new approach on wearable game design and its evaluation

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ABSTRACT

As technologies evolve and computer systems shrink to the size of matchboxes, also their field of application shifts in new directions. Our permanent companions, mobile phones, personal digital assistants and laptops, have made their contribution to dislocate our workplace from the little office to anywhere we want to work. A similar trend is happening in the field of video and computer entertainment. Mobile and location based games using wearable computers are the next step to drag us out of our homes, away from TV or computer screens, where we were used to play, and lead us into the new worlds of mixed realities. Since game platforms and interfaces change as well, we also have to redefine the way we create and design this sort of game. This paper displays the approach we chose to find a concept for an innovative wearable game and how to consider the characteristics of today's wearable hardware when developing a game. Moreover it will give an outline of the game, that our approach led us to.

Keywords

Mobile games, physical environment games, pervasive computing, ubiquitous computing, game theory, design principles

1. INTRODUCTION

PEnG is a project in the University of Bremen and the Center for Computing Technologies. It deals with the design and development of *Physical Environment Games*. Starting in late October 2005, the two-year project under the guidance of Prof. Dr. Herzog, Dr. Kenn and T. Nicolai, which consists of 23 participating students, has aimed their efforts at the development of a game on a mobile platform to shift the game location from the virtual to the physical world.
Such a game has to fulfill certain constraints of different game genres like mobile and pervasive games. That means particularly the *anytime and anywhere* paradigm, which implies that the environment and its change is recognized by sensors and that the user has the ability to play the game as his timetable allows it.
The goal of this project is an innovative game concept for a **wearable computing game** and its realization. Additionally we want to create a concept for a new wearable game design method.
The special requests and features of such a wearable game require a different design and development flow than a normal design process does. These aspects will be more specified in the **Methods** section. Following this, we present the result of our concept evaluation phase in the section **Game Concept**, and we show some of the games, that influenced us in the shaping of our idea in the **Related Work**. We conclude our paper by pointing out our results concerning wearable game design and by evaluating the technologies we analyzed so far.

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2. METHODS

This section is tripartite. First of all we will talk about the way we use different technologies and analyze them along some criteria.
In the second part we are going to illustrate some game test runs that we did during our first two terms to evaluate the outcome of the game prototypes, that we had developed so far.
The last section gives the reader an impression of our approach of finding a game concept, including analyses of already existing and newly found ideas and their eventual evaluation to make them comparable.

Before we can analyze technologies for wearable games we have to consider useful technologies for game design. In order to do that we first implemented some spikes for localization by using *GPS*. We used a *Anycom Bluetooth GPS* device and mapped the given information onto a virtual map. This spike helped us to realize the inaccuracy of *GPS*. Along with this awareness we decided to use this technique only for mapping and not for purposes like verifying contacts to other players.
Along with the issue of contact verification between players we implemented spikes for Bluetooth scanning. Just like *GPS*, these results were similarly disappointing. The scanning accuracy was less than we would have expected. Furthermore such a scan loop takes too much time for an action based game. In our test sometimes the players were too fast to be successfully detected by the scan.
Beside these two techniques we also looked for some data

streaming technologies. We first decided to use a wireless local area network, but even if we used a powerful access point, the covered area would be to small for a mobile game. An area which is big enough for playing would require too many access points. So we decided to look for a combination of ad-hoc networks and wireless GSM networks. Unfortunately the range for an ad-hoc network is according to our tests never bigger than 20 meters, which also did not meet our expectations.
Our next steps will be to analyze technologies like *UMTS* and *WIMAX*.

Along these techniques for wireless communication we also implemented spikes for video capturing. These spikes revealed new problems about the amount of data which is to be transferred to other players. For streaming realtime pictures to another team member we would need a large bandwidth of at least 2 MBit/s. Due to this problem we discarded this idea very fast.
As an alternative we decided to implement some spikes for audio communication between players. In this case the bandwidth was not a problem for any wireless network, but it turned out not to be an adequate alternative for a video connection among team members.

Aside from this procedure for evaluating different technologies, we analyzed games by implementing adaptions of existing games.
When our project started in late 2005, we began development on three different ideas for mobile games involving wearable computers. Doing this we were able to collect first experiences with the common technologies in this field of research. Two of our three ideas made it to a desktop played prototype and were also tested in live outdoor game sessions without wearable devices.
Although the live sessions were held under conditions that differed from the specified game concepts in terms of field size, various player classes and team communication and moreover were not able to benefit from the advantages of wearable devices, those sessions showed us, that our ideas were much too vibrant.
One of them being a Stratego adaption for wearable devices, the other one being loosely based on a multiplayer game mode, known as 'domination', in which two opposing teams collect points by being in range of a checkpoint.
Since in both live sessions the size of the field was not large enough to prevent the opposing teams from seeing each other right from the beginning, most tactical thoughts were disregarded, resulting in an exhausting endurance run. Even though the experienced dynamics can be traced back to the fact that the outdoor sessions were not held under the specified conditions, the games were still too fast, giving us a requirement to check for in our upcoming ideas.

In addition to these two test sessions without wearable devices, we recently finished testing another game that we implemented, which is just a simple adventure game, that sends the player through a story with linear order from one point to another one. The main idea behind it was to check out how our Xybernaut system[12] works with the Bluetooth devices, which we used to trigger the story events. In our setting the player, who was wearing a Xybernaut system with HMD and Bluetooth receiver, was directed into the approximate direction, where he would find the next contact person. As soon as the Bluetooth devices began to communicate, a screen would pop up, that would give him additional information to help him find the person. After he was given the information he needed, his contact would point him into the direction of the next person to get to.
As a result we know now, Bluetooth communication fits our needs as long the scanning process is not time critical, meaning that the use of Bluetooth in our upcoming game depends on the pace of the game.

After using these first games to get acquainted with our new field of research, we restructured our project to build two teams. One, the Concept Team, was to find a final concept, that we could concentrate our efforts on, and another one, the Technology Team, was to gather all the information and experience about technologies, which we might use in the implementation of our final concept.
To find a concept, we created a list of games, not restricted to any platform, that constituted, in our opinion, milestones in game history. These games were then broken down into their core-elements, which in turn were analyzed regarding technical and economical aspects, as well as the theoretical amount of fun, that each element would bring to the table.

The list of analyzed games included classic PC-games like, *Dune 2* [6] or *Doom* [7], current massive multiplayer online role playing games like *World of Warcraft* [9] up to mobile games like *Uncle Roy all around you* [10] and children's games like *Cops and Robbers*.

As an example, we will now describe one of these game element analyses.
A very important element in today's games is a multiplayer mode. The multiplayer games we analyzed showed that all of them contained concepts like interaction and communication among players, formation of teams and the pursuit of a common target.
From a technical point of view these concepts result in a handful of problems like wether to realize the communication by establishing an audio connection between the players or by implementing it via a text input interface or wether to manage the game status from a common server or not. The fact that all connections need to be wireless displays an additional issue.
After pointing out the problems, we checked out which technologies could solve them. Possible solutions for an audio connection that allows fluent data transfer at a reasonable bandwidth could be using Bluetooth, UMTS, GPRS, GSM or Wireless LAN. Which of these technologies to use depends on the financial resources, differing prices for traffic and hardware and existing infrastructure in our environment.
These issues are dealt with by a different subgroup within the Concept Team. In this case technologies like Bluetooth and UMTS disqualify themselves by providing too little coverage and not providing service at all in our region respectively. A technology like Wireless LAN on the contrary poses itself in a pole position by its easiness to be set up and its affordability.
The third step of each analysis was to theoretically evaluate the importance of a game element by measuring it on a scale from 0 to 10. Depending on the evaluation of seven differ-

ently weighed criteria, that was again measured on a scale from 0 to 10, each game element could reach a minimum of 0 or a maximum of 10.
The criteria included the question for a contribution to the long term *motivation* of a game element, to the degree of *interaction*, to the amount of *influence* it would have on the resulting game, wether it features *competitory* elements, whether *cooperation* is possible or even necessary, wether it fits in with our *target group* and how dependent it is on a certain *number of players*. The weights of these criteria ranged from 5 percent up to 22.5 percent.

Following this analysis period we started collecting new ideas using a brainstorming technique, that is referred to as *Brainwriting* or *Group Passing Technique*. We came up with 15 ideas, that have been created and developed by the entire Concept Group. We tried to let those concepts flow in, that have been evaluated best in the analysis period. Since some of the newly found ideas had a lot in common, we decided to merge them together, leaving a total of seven ideas. By discussing the various concepts, it was pointed out, that some of them were already implemented, did not seem to have enough potential for a game or were not precise enough.
Three of the remaining four ideas were decided to be variations of role playing games each of them only with another main feature, like trading or character improvement. This left us to choose between some kind of role playing game (RPG) or a mobile game version of a realtime strategy game (RTS).
We decided in favor of the real-time strategy game, because we thought that a lot of mobile and/or wearable games, that have already been developed contain RPG elements and we did not want to develop yet another one. Additionally in contrast to some of the RPG-based ideas, this type of game features among other things a multiplayer-mode, which we considered to be highly motivating and is thought to have a higher mobility factor.

3. GAME CONCEPT

Bringing the concept of a realtime strategy game on wearable devices makes it necessary to think over the realization of the classical game concepts.
This chapter will introduce the game idea based on a game description considering the game preparation, the game operations and the goal of the game, and in conclusion the particularities of the game concept will be pointed out.

Before starting the game there are certain preconditions to be fulfilled.

A game server has to be available and an upcoming game session has to be registered there. All the players need a permanent connection to the server updating their actions and receiving information on the virtual world mapped onto their real environment. With the purpose of feeding the game server with localization information each player is equipped with a GPS device.

The dominant concept of the game is *using the global position of the player as mouse pointer.*

Now the game environment is set up and the game is ready to be started. The main task during gaming is to construct structures to extend the own base and by ordering these structures to perform tasks.
The assigned tasks can be categorized in three topics. One of them is facilitating natural resources, another one to convert them into usable goods for trading and gaining monetary values. The third topic is defending the own base, exploring new areas and conquering new regions from other players *(see Fig.1)*.

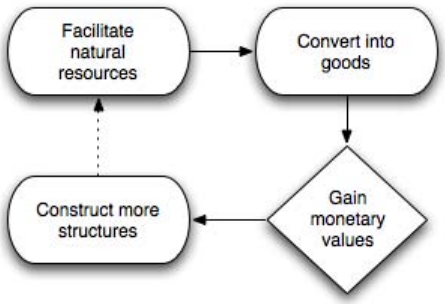

Figure 1: Economic cycle

A game session starts with the player moving around selecting where to place his basic building. A *build interface* shows the player the possible extensions from where he selects one. The information is sent to the server where it is saved. After building one part other extensions become available so that the size of the player's base grows.
As mentioned above extending the own base is not the only operation that can be performed.

The player is responsible for the organisation of the production of goods and their transport between the different industries he has constructed. The production of goods implies the resource facilitation and its further production.
After finishing a construct the player visits it and another *action interface* shows the possible operations. The player selects one and the building tries to process it until the player interrupts the action. Now another process in another building may be invoked.
The transport of goods and their production is automated *(see Fig.2)*.

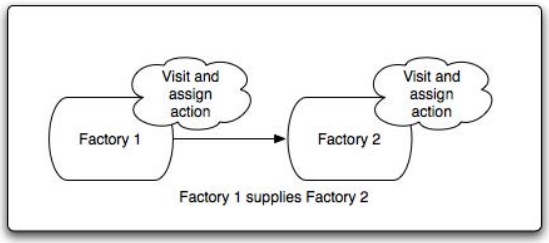

Figure 2: Economic cooperation

If the player e.g., wants all goods from industry1 to be delivered to industry2 he has to visit industry1, select the

goods and then he visits industry2. Then industry1 intends to deliver goods to industry2.

Strategy is not only required for ensuring a prosperous economy, but also and even more for winning the game by defeating the opposing player(s) and protecting the own base by military units and buildings. Commanding those works similarly as commanding the production of goods.
In order to protect the own buildings from other players and to extend their territory by exploring new areas military building should be placed. These buildings are occupied by a defined amount of own soldiers.
Attacking an opponent follows the same procedure as transporting goods. The player visits his military building and selects the amount of soldiers for the attack. Then he visits the target building and the attack starts. The winner of the attack keeps the target building. If the attacker occupies a military building all of the opponent's constructs close to the occupied structure will be destroyed.

The game ends when a predefined state is reached, e.g., the own base is expanded to a certain size, a number of goods is reached or all opponent buildings are eliminated from the map.

The game concept combines a lot of necessary features of a mobile game. It is innovative, as our research introduced in the **Methods** did not bring up a comparable game concept for mobile environment games. Additionally we use new networking technologies like WLAN, GPS and AGPS. A more detailed information on the techniques used is written down in the **Methods** section.

The main concept for a game in the environment is the ability of competing with other players. Our concept integrates various multiplayer gaming options. One of them is managing the own base together with another player, another one is competing with others on the map. Certainly the two concepts can be merged in one game.
When designing a game that is played on the run the examination of how to present the data through interfaces as part of the Human-Computer-Interaction is one of the major research parts together with integrating alternative input devices for the special game tasks.
Using the coordinates of the user as a pointer on the map represents an alternative implicit interaction in contrast to the traditional WIMP[1] paradigm. The only explicit interaction takes place when the player assigns an operation to a building. But at this point in time he is not in motion anymore. For this a special interface consisting just of menus is used and is navigated via an input device based on classic input devices for wearable computing.

4. RELATED WORK

One game that has certainly left his footprint on most realtime strategy games is *Dune 2* [6], which hit the market in 1992 and was developed by Westwood Studios. It is often referred to as the origin of the popular realtime strategy genre.
The setting is based on the 1984 movie *Dune* by David Lynch and the 1965 novel of the same name by Frank Herbert, respectively. Three different Houses fight for the dominance on the resource rich desert planet Dune. No matter which House the player chooses, the basic principle of the game is to build up and defend the own base, to conquer enemy territory by defeating all opposing units in the area and to harvest the spice, a resource that is only to be found on this planet. The player uses this resource to pay for all the units and building that he produces.
Additionally to the basic units, each House has some units with unique attributes. This and the fact that each House represents a different kind of ethical belief, like noble, evil and perfidious, are the influences that lead to the player's House of choice.
The principles of building and expanding a base, harvesting some kinds of resources and defeating one or more enemies to become ruler of the game world are the corner stones of almost every realtime strategy game, that has been developed since then.

Since the classic realtime strategy combat system is much too dynamic for our concept, we had to think of a different approach, that we found in the 1993 realtime strategy game *The Settlers* [11], that was developed by Blue Byte Software. Although this game emphasizes a peaceful beginning of base building and resource processing in a colorful world, the main goal is once again military dominance. But different from *Dune 2* or various other RTS games, the combat system does not work by sending a rush of tanks into the enemy base, but by conquering or destroying the enemy defense buildings, leaving the surrounding environment in the attacker's hands.

ARQuake [3], developed at the University of South Australia in the year 2000, it was one of the first projects, that made a connection between the physical and the digital world by augmenting reality with virtual game elements.
The idea behind it was to transfer the first person shooter Quake [8], developed by id Software in 1996, to a mobile game using technical equipment, like differential GPS for localization, inertial sensors for orientation and optical sensors for augmenting reality. The real world is superimposed by virtual elements of the game, like doors, enemies and power ups. To make all this possible, it was necessary to make a three dimensional model of the physical environment, that the game is played in, to map the virtual elements onto the real surroundings.
Since the player controls his virtual alter ego with his own movement of body and head and since the game itself requires a lot of performance, the player is equipped with the Tinmith backpack, that is filled with hardware to take care of motion tracking, localization, etc.
ARQuake is definitely a prime example when it comes to wearable augmented reality gaming, but since we have experienced how physically demanding wearable games can be, we will try to keep the hardware requirements in the realization of our game concept as low as possible to allow the player a preferably high amount of freedom.

Even though this is pretty impressive, we will try to keep the hardware requirements for our game concept a little more handy.

[1]Windows, Menus and Pointers describe the classical computer interaction

5. CONCLUSIONS

Finally we see, that the development of a game in the area of wearable computing is influenced by many different problem areas. One is the technical feasibility of communication. The communication of a system in a widespread area is hard to handle. Currently communication technologies have different kinds of drawbacks for mobile gaming. Using wireless local area networks means to prepare the gaming area which stands in contrast to the idea of pervasive gaming. Other forms of communication between systems are not fast enough or not available everywhere. All these disadvantages of wireless communication technologies have to be taken into account when we talk about data transfer between clients and server.
Even though other technologies like Bluetooth have their weaknesses, when it comes to games, that require a fast device detection, they are useful for slow-paced games as our tests have shown us.
As an alternative to the communication problem new technologies like *WIMAX* could be considered. For wireless data transfer on the other hand, we also could use *UMTS*. But since we have not made any tests with these technologies, for now we can only assume that they qualify for our demands.

Locating a player can be realized in different ways depending on the requirements that need to be fulfilled.
The classical way of localization with *GPS* is sufficient enough for slow-placed games as we intend to develop one. In a more dynamic game we would need more exact data which could be obtained by using techniques like *Assisted GPS*.
Locating players in a building, using Bluetooth for example, is also very difficult and with the current requirements and preparations for our purpose nearly useless. Preparing the game area like this, would once again be contradictory to the idea of pervasiveness .
After all the hardware we are going to use for gaming is not as powerful as it could be, but it will fulfill the requirements of mobile and wearable gaming.

In game design the fun of playing a game is the main feature which has to be realized by the technologies. Keeping the fun in a wearable game is bound to several constraints.
Considering that the game is played in motion the game developer has to think of strategical elements to slow down the action with the result of equaling the chances of physical stronger and weaker players. Many of the concepts in the **Methods** section, when realized on wearable devices as a pervasive game element, lead to a sports competition what is usually not the goal of a computer game. The idea of direct interaction between the players in motion often leads to fleeing and chasing. In a desktop game the platform determines the players strength independent from the real physics.

Wearable Computing claims not to interfere with the primary task of the user. Common computer games grab the user's full attention.
That contradicts to the expectation of a user playing a computer game. What he intends is to take a complete break from his environment. In a wearable game therefore both paradigms are fed by the expectations of different user groups. One demands a permanent game, another one a session-based game.
In both cases the design of the interface has to be adapted to the mobile use. The common graphical representation of data would most likely disturb the motion and consequently the game experience of the user. The interfaces need to follow other design principles mainly influenced by context awareness. A user in motion is not able to interact with his system all the time. The information has to appear when it is needed. That filtering also leads to less crowded screens, which supports the smaller displays of the wearable devices. In our game concept receiving the GPS coordinates provides the necessary context information. When being attached to a wearable computer while playing it is necessary that the player's view is restricted as little as possible. Therefore graphical displays which support the see-through mode are a good choice.

[2].

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