The Smart Dice Cup: A Radio Controlled Sentient Interaction Device

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Abstract. In this paper, we present the Smart Dice Cup, a novel interaction device aimed at gaming applications in smart home environments. The Smart Dice Cup is used in a similar way as a traditional leather dice cup to generate random numbers. Integrated accelerometers relate the shaking of the device to the resulting rolls of the dice. In addition to an autonomous stand-alone mode, where the Smart Dice Cup serves as self-sustained gaming system, the device is also capable of communicating with its surrounding environment serving as an input device for other pervasive gaming applications.

1 Introduction

There is a growing trend in the computer gaming research community to augment traditional video games with aspects from the real world, e.g. [1], [2], [6]. These hybrid or pervasive games combine the virtual nature of traditional video games with physical and social context, thus creating immersive gaming experiences that pervade the boundaries of virtual, physical and social domains [4].

We have been active in the field of pervasive tabletop games that take place in smart home environments and provide tangible interfaces that borrow interaction techniques from traditional board games (see fig. 1). The central idea is to combine the advantageous elements of traditional board games and computer entertainment technologies [3]. Board games emphasize the direct interaction between human players. They sit together around the same table, facing each other at an intimate distance. Their close face-to-face interaction integrates discussion, laughing, and all kinds of non-verbal communication hints creating a rich social situation. Complementarily, playing computer games introduces many highly interesting possibilities that enhance the playing experience. Game presentation is enriched with audio and visual support and game content is limited only by the imagination of the developers. The drawback of computer games, however, is the lack of social interaction in a face-to-face setting, since the players' notion of each other is mostly conveyed by screen and keyboard. To combine the strengths of both game types and to provide interaction metaphors appropriate for face-to-face group situations, it is a promising approach to augment the proven tangible interfaces from traditional board games [8] with unobtrusive pervasive computing technology.

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2 The Smart Dice Cup

Dice are crucially important components of a wide range of games. They are used for creating variations in the game flow. By rolling dice, an element of chance is introduced to an otherwise static and deterministic flow of game actions. The chance in the dice, however, is not equal to the generation of a random number. Rolling dice involves both a physical act and skill (some people and some dice roll better results than others) as well as a social mechanism to supervise and control the physical act, because cheating is a common phenomenon associated with this particular way of adding variability to games. Hence, rolling dice is a very interesting example of a gaming interface that is particularly suitable for a computer augmented realization.

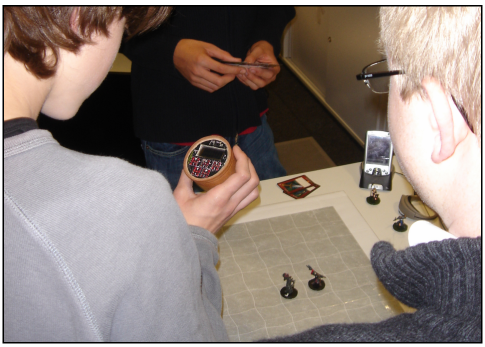

Fig. 1. A pervasive tabletop game with the Smart Dice Cup being in use

In order not to lose the physical and social aspects of rolling dice by simply creating random numbers in a computer application, we tried to preserve the multi-faceted nature of dice-rolling in our computer adaptation. Due to the size and feasibility problems associated with augmenting individual dice with respective sensor technology, we integrated multiple dice into one single smart artifact.

2.1 Interaction Design

The interaction with the device was designed to be as similar to a traditional dice cup as possible. To generate random numbers, the device is lifted, shaken, put on a plain surface upside down, and then finally lifted again to see the results. However, in contrast to traditional dice, the sum of the spots is not counted from the physical dice after being tossed on the surface of the table. Instead, the spots are displayed via light emitting diodes (LEDs) on the surface of the dice cup's top.

Shaking the device also emits a sound mimicking the sound of shaking a traditional dice box, although the integrated sound hardware does hardly deliver sound of acceptable quality. Since the smart dice cup is capable of communicating with the environment via radio transmission, it is more preferable to let another sound source outside the device perform the respective audio output. In addition to the basic interface of shaking, dropping and turning the device, there is also a conventional button interface with a graphical display integrated in the top surface of the dice cup as shown in figure 2. The button interface is used for advanced configuration of the device when it is in autonomous mode and no other interface such as a respective GUI application (running on a nearby PC) is available or when single dice are to be “held” or “released”, i.e. when they are to be included or excluded from tossing.

Each of the five dice displayed on the surface of the dice cup consists of seven red LEDs that represent the spots of the respective die. Whenever the device is shaken, the respective light patterns change in accordance to the tossed result. A small green LED is used to indicate whether the respective die is held or released, i.e. if its face changes when the device is shaken. To toggle between holding and releasing a die, a small button is associated with each die that turns the respective green LED on or off with each press, thus ensuring an intuitive way of changing the individual held states by providing visual feedback and adhering to the Gestalt law of proximity regarding the button layout.

Fig. 2. The user interface of the Smart Dice Cup

The graphical display features two lines of eight characters each and is used for any optional interaction with the user beyond the scope of mere dice rolling. It is accompanied by two buttons on the left and right of it labeled “SELECT” and “OK” that allow for simple dialog navigation with “SELECT” cycling through a list of menu options and “OK” confirming the respective choices. The dice cup software currently includes a simple state machine that toggles between several menu states such as “Free Play” (the default state in which the device is used for tossing only or “Game” (allowing to chose one of currently two built-in mini games) or “Options”. The device can be turned off and on and put into a remote controlled mode with a respective three-state-switch above the graphical display. The remote controlled mode allows the device to be controlled from the environment via radio transmission as discussed in the following section.

2.2 Operating Modes

The Smart Dice Box was designed to function both as an autonomous smart artifact that performs its functions independent of the environment and as an interaction device that offers its services to other instances (software applications, smart artifacts etc) in the vicinity of the smart home environment. For the stand alone operating mode, the device’s integrated memory and the built-in games offer added value compared to a traditional dice box. For instance, it replaces pen and paper when games like e.g. Yahtzee are played that require the counting of individual results. In fact, a similar game (the Counter Game) is currently implemented on the device, albeit simpler than its original.

When the dice cup is brought to a smart environment, it can be put into a remote controlled mode in which it is both able to receive commands from the environment and to convey back information about its own state. As illustrated in figure 3, an application in the environment can utilize the information from the device and create a respective virtual counterpart.

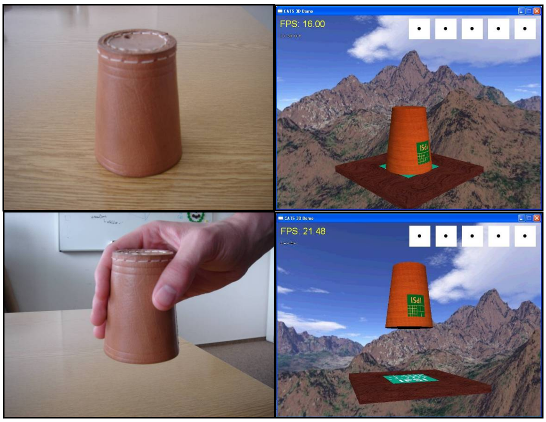

Fig. 3. The physical device and its virtual counterpart

This virtual counterpart interprets and displays the device's radio signals conveying both the orientation/ shaking status measured by accelerometers and the current spots on the virtual dice. To visualize the received dice box data, a 3D view of the dice box is rendered illustrating the orientation (whether the device is upside down) and the presumed vertical position. The spots of the dice are visualized as respective bitmaps and an optional sound output of dice being shaken can be generated. The application is furthermore capable of transmitting the received dice data to other software components in a pervasive games setup, so that the dice cup can be exploited as a central tangible input device for any kind of pervasive game.

In the same way as data can be read from the device, the dice cup can also be remotely controlled including individual dice being held or released. Furthermore, additional functions that are not available on the device interface are exposed for the remote software. This includes setting the sides of individual dice and showing messages on the graphical display. It is also possible to change the random number generation on the device with the introduction of so called "luck dice".

This "luck dice" concept relates to the way the random numbers are generated. The seed of the random number generator on the device is initialized with the data from the accelerometers integrated in the cup that measure the shaking of the device. This allows for modeling an important aspect of the physical act of rolling dice: Should a person be able to shake a traditional dice cup two times in exactly the same way, she would roll exactly the same results. The corresponding is true for the Smart Dice Cup, although in reality nobody should be capable of doing this with any of the two devices. Depending on the range of respective transformations of the accelerometer data, one could however investigate in how far the sensor data can be blurred or otherwise modified to allow for perceivable influences of the physical act of shaking and the respective results.

In a remote controlled operating mode, the dice cup allows for tweaking the amount of “luck” a person has by performing additional rolls with respective “luck dice”. This is an interesting twist to the traditional realization of luck as a trait, in which a player rolls against an arbitrary luck criterion of differing magnitude. By introducing luck dice, the spots rolled correspond directly to the result instead of being valid only in combination with an external criterion. Each luck die associated with the rolling of a target die has a 50% chance to affect the result of the target, if it does, a second roll is performed and the higher result becomes the target.

2.3 Technical Realization

The core of the Smart Dice Cup consists of a Smart-Its particle computer equipped with additional LC displays, LEDs and switches. Such a particle is “a platform for rapid prototyping of Ubiquitous and Pervasive Computing environments, for Ad-Hoc (Sensor) Networks, Wearable Computers, Home Automation and Ambient Intelligence Environments. The platform consists of ready-to-run hardware components, software applications and libraries for the hardware and a set of development tools for rapid prototyping” [7].

The Smart-Its particle platform is built around two independent boards, a core board that consists mainly of processing and communication hardware and basic output components and a sensor board containing a separate processing unit, various sensors and actuators. In the case of the Smart Dice Cup, these were accelerometers, other sensors include light, humidity, temperature, or force/ pressure. Figure 4 shows the internals of the device.

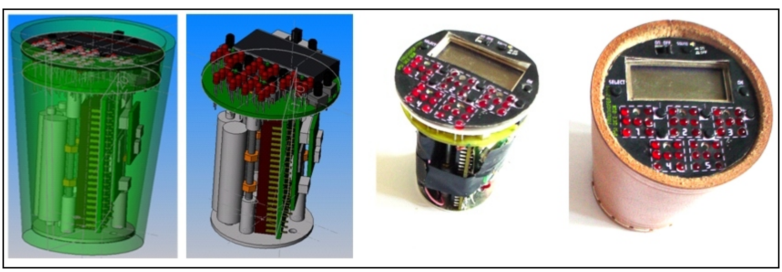

Fig. 4. The internals of the Smart Dicebox

The random number generator implemented is a Mersenne Twister [5] that is freely available as portable C-code. It has become a popular algorithm, since it passed the relevant, stringent statistical tests and is still comparable to other modern random number generators in terms of speed, hence making it a suitable algorithm for an embedded microcontroller such as the PIC16F876 used with the particle platform integrated inside the dice cup.

2.4 Next Steps

To demonstrate and explore the benefits of the Smart Dice Cup and other related interaction devices in a rather complex pervasive gaming application, we are currently developing a “Dungeons & Dragons” style tabletop roleplaying game called “Caves & Creatures” that makes extensive use of the device. Next to the integration of RFID augmented playing cards that represent items, weapons, armor, etc. and a physical game board that is used for positioning and moving game characters, the Smart Dice Cup will be the single most important pervasive interaction device, because rolling dice is a central component of any tabletop roleplaying game. Until we will have the game running and ready to test in a controlled experimental setting, our own preliminary observations using the dice cup are very positive, for the user interaction is really as intuitive as with a traditional dice cup. The benefits of not having to worry about the link between the physical act of rolling dice and informing a computer application about it are obvious. Finally, the capability of operating the device in a standalone mode promotes its use also outside the laboratory.

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