Manipulating Multimedia Contents with Tangible Media Control System*

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Abstract. We propose Tangible Media Control System (TMCS), which allows users to manipulate media contents with physical objects in an intuitive way. Currently, most people access digital media contents by exploiting GUI. However, it provides limited manipulations of the media contents. The proposed system, instead of mouse and keyboard, adopts two types of tangible objects, i.e. RFID-enabled object and tracker-embedded object. The TMCS enables users to easily access and control digital media contents with the tangible objects. In addition, it supports an interactive media controller which can be used to synthesize media contents and generate new media contents according to users' taste. It also offers personalized contents, which is suitable for users' preferences, by exploiting context such as a user's profile and situational information. Accordingly, the TMCS demonstrates that a tangible interface with context can provide more effective interface to fulfill users' satisfaction. Therefore, the proposed system can be applied to various interactive applications such as multimedia education, entertainment and multimedia editor.

1 Introduction

With rapid development of computing technologies, various media contents (e.g. music, image, graphic and movie, etc) are now available in the form of digital contents which can be accessed through computers. Thus, use of media contents has increased and they play an important role as entertainments in our daily life. However, many people still have difficulties in using the digital media contents even though Graphical User Interface (GUI) mitigates the problem to some extent. Especially, the elderly, who are not familiar with computers, feel uncomfortable while manipulating digital media contents with keyboard and mouse. Moreover, the GUI is not convenient enough to let users enjoy digital media contents and to manipulate the media contents according to their taste in the space of daily life, such as living room. Recently, in order to overcome such inconveniences, Tangible User Interface (TUI) [1] has been proposed as a new kind of interface since TUI allows users to intuitively control digital information by using physical objects.

Ishii et al.[1] proposed Tangible Bits, which allows users to present and control digital information by using elements existing in everyday life, such as sound, light, airflow and movement of water. For example, MusicBottle[2] and genieBottles [3]

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use glass bottles as interface for playing music or telling a story. They link digital media contents to physical glass bottles and exploit the human sense of touch. MusiCocktail [4] allows users to blend various kinds of music in the way they mix their beverages. Musical Trinkets [5] provides users with physical objects, e.g. dolls and finger rings, to play several music pieces and insert effective sounds. It allows users to generate synthesized music by using their hands. BlockJam[6] allows users to create as well as to control the tempo of the music by assembling blocks or exploiting several buttons onto the blocks. These applications provide users with an interactive music player and entertainment factors. However, they are limited in achieving users' satisfaction since they offer same media contents to all the users in same way without considering users' taste.

In order to improve the current TUI, we propose TMCS (Tangible Media Control System), which combines the concept of TUI with RFID tag [7] and tracker. The TMCS allows users to intuitively manipulate media contents by using tangible objects, such as CD, doll, etc, which are physical objects with RFID tags and a tracker. In addition, it offers personalized contents according to the implicit context, e.g. a user's profile or situational information using ubi-UCAM (a Unified Context-aware Application Model) [8]. The proposed system consists of three key components; tangible objects, context recognizer and media controller. Tangible objects, physical objects with RFID tags and a tracker, provide an intuitive interface to users. Context recognizer creates context [9] of a user and tangible objects; and media controller allows users to manipulate the media contents.

The proposed TMCS has following advantages. It provides novice computer users with an intuitive interface for media contents. Thus they can easily access and control digital media contents with tangible objects. In addition, it offers an adequate environment for users' satisfactions, by providing personalized contents according to users' preference. Furthermore, it enhances entertainment value of media contents since it allows users to naturally manipulate media contents according to their taste. Consequently, TMCS can be applied to various applications in the fields of interactive training, entertainment, education, media editing, etc.

This paper is organized as follows. In Chap 2, we describe architecture of the proposed TMCS, and in Chap 3, we show the implementation of TMCS. In Chap 4, we illustrate experimental set up and results about usefulness of the proposed system. Finally, we discuss the future works in Chap 5.

2 TMCS: Tangible Media Control System

As shown in Fig. 1, the proposed TMCS consists of three key components; Tangible objects, context recognizer and media controller. Tangible objects offer an intuitive interface for accessing and manipulating media contents. Context recognizer senses any changes in environment and creates contexts of users and tangible objects from the sensed signal. Media controller provides different media contents according to users' preferences and allows users to manipulate and synthesize the contents.

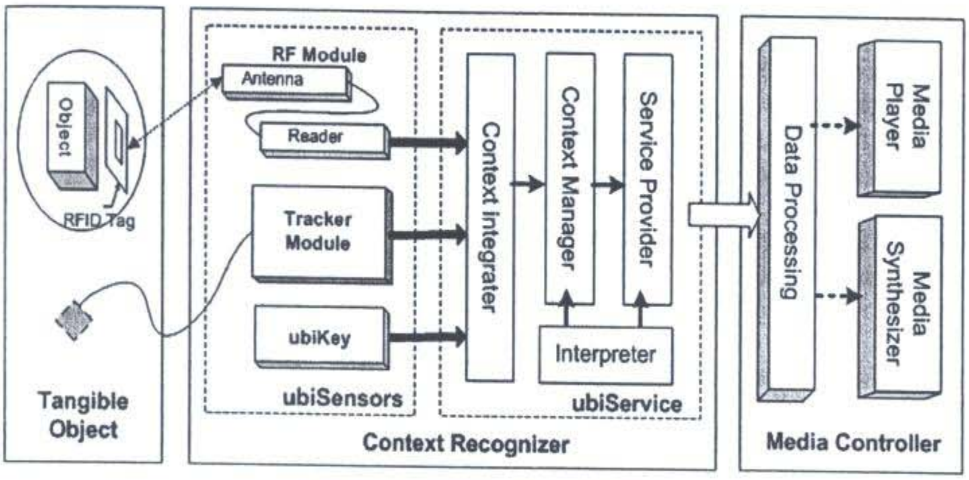
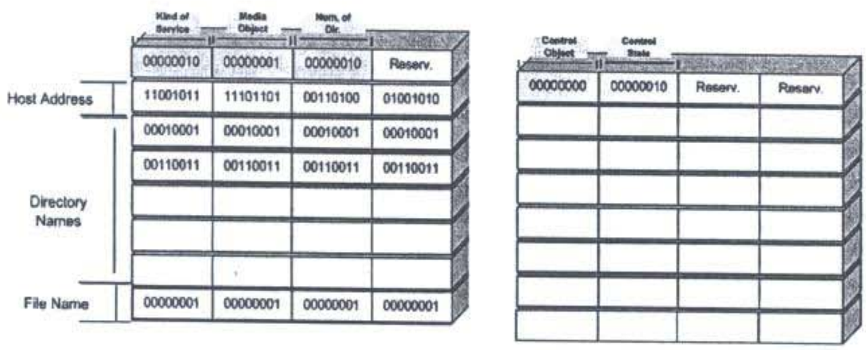


Fig. 1. The Architecture of TMCS



(a) Media object (b) Control object

Fig. 2. The Memory of RFID tag in Tangible Object

2.1 Tangible Object

Tangible object links a physical object to digital media contents and allows users to easily access the digital contents by using the object. Additionally it offers an intuitive interface for natural manipulation of the media contents according to users' taste. It has two types of tangible objects, i.e. Media object and Control object.

Media object provides users with an intuitive interface for accessing digital media contents by using a physical object, which is commonplace in our daily life. Each object has an RFID tag. As shown in Fig. 2 (a), the RFID tag contains URL information of media contents. The contained information consists of the number of directories, a host address storing the digital media contents, metadata of directory and file, etc. Therefore, without knowing the explicit URL of the media contents, users can easily access digital media contents through the media object.

Control object allows users to naturally manipulate digital media contents in accordance with users' preferences through their hands. It has two types of objects; one is RFID-enabled object, and the other is tracker-embedded object. As shown in Fig. 2(b), the RFID tag attached to an RFID-enabled object contains control state information of a convenient media player. By rotating the RFID-enabled control object, users can control digital media contents, e.g. Play, Pause, Stop, Fast forward, Rewind, and Increase/Decrease Volume. On the other hand, a tracker-embedded control object is embedded with a tracker to a physical object. It also creates commands to execute complex manipulation of media contents, e.g. generating new music pieces, and changing musical instruments or note, according to changes of parameters of the tracker. Therefore, users can manipulate media contents naturally by using the two kinds of control object.

2.2 Context Recognizer

Context recognizer creates a meaningful context from sensed signals and translates it to an appropriate context for media controller. It consists of ubiSensor, an intelligent sensor that generates a preliminary context from sensed signals; and ubiService, an application that integrates the preliminary contexts to generate a final context.

ubiSensor senses changes in environment and generates a preliminary context in the form of 5W1H (Who, What, Where, When, How, Why). It consists of RF module, tracker module and ubiKey. The RF module reads data from an RFID tag of tangible object, e.g. URL information of media object or control state information of control object, and then creates a preliminary context for the tangible object. The Tracker module also detects changes of 6 parameters of tracker, and then generates a preliminary context of tracker-embedded control object by interpreting values of these parameters. Similarly, ubiKey creates a preliminary context of a user from his or her profile stored in the ubiKey. Table 1 shows the preliminary context created by each ubiSensor.

Table 1. The preliminary Context of ubiSensors

ubiSensor	Context (5W1H)	Context Information
RF module	What	Metadata of Directory and file name
	Where	Server IP address
	How	Control state information
Tracker module	What	Musical instrument / note/octave
	How	Control state information
ubiKey	Who	User name
	When	Entrance time

ubiService efficiently integrates preliminary contexts generated by ubiSensors. In addition, it creates an integrated context reflecting the user's intention as well as explicit commands. As shown in Fig.3, it consists of Context Integrator, Interpreter, Context Manager and Service Provider. Context Integrator collects preliminary contexts from RF module, Tracker module and ubiKey. Then, it computes "why" data representing a user's intention and creates an integrated context. Interpreter provides an interface to let users define context conditions and functions that must be executed according to the conditions. Context Manager creates a final context, which is suitable

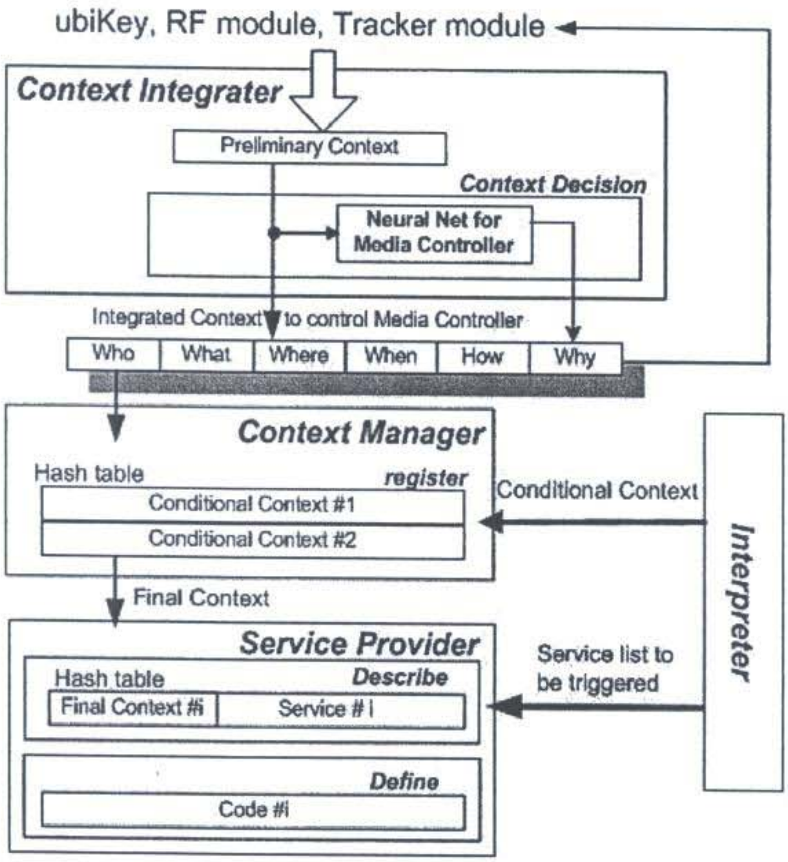


Fig. 3. The Data Flow between components of ubiService

for a media controller, according to context conditions defined by users. Service Provider executes the specified module of media controller according to the final context and the context condition. Fig. 3 shows data flow between the four components.

2.3 Media Controller

Media controller offers personalized contents, i.e. provides different media contents in accordance with users' preferences. It also allows users to control or manipulate the media contents according to their taste. It is composed of data processing module, media player and media synthesizer.

Data processing module analyzes final contexts generated by context recognizer. It extracts user's information and control state information or generates URL of digital media contents. In order to generate URL of digital media contents, it extracts IP address of digital media contents server from the final context. Then it accesses database of the server. It also finds substantial directory and file name by exploiting metadata of directory and file in final context. Finally, it combines them and then completes the URL of digital media contents.

Media player supports a simple control according to analyzed data by data processing module. Thus, it retrieves digital media contents by using the URL generated from data processing module. It also allows users to control the media contents according to control state information related to playing (e.g. Play, Stop, Pause, Fast forward, Rewind) and related to volume(e.g. Increase/Decrease Volume).

Media synthesizer provides an interactive environment which enables flexible manipulation of digital media contents according to users' taste, e.g. mixing several media contents, inserting sound effects and so on. Additionally, it allows users to change musical instruments, note and octave of the instrument. Furthermore, it provides users with "history service". That is, media synthesizer maintains a log of manipulation, such as media contents, selected musical instruments and note, etc. Then it analyzes user's preferences such as preferred musical instruments or media contents. When the user accesses it later, it provides personalized media contents and musical instruments according to the user's preferences. Therefore, it offers an environment which can efficiently satisfy user's expectations.

3 Implementation

As shown in Fig. 4, the proposed TMCS is installed in ubiHome, a test-bed of home appliances for ubiquitous computing. In order to allow users to experience TMCS in a smart home environment, RF module and Tracker module are attached under a table in a living room. Thus, users can naturally interact with digital media contents while sitting on a sofa. Additionally, it provides an environment where users can experience the results of manipulation through TV and speakers in living room.

As shown in Fig. 5(a), the Media object, one of tangible objects, is embedded with an RFID tag (Texas Instrument's [10] transponder, RI-I01-110A) to physical objects, such as CD, picture, doll, etc. Thus, digital media contents are automatically retrieved when users put the object onto the table. As shown in Fig. 5(b), the Control object, the

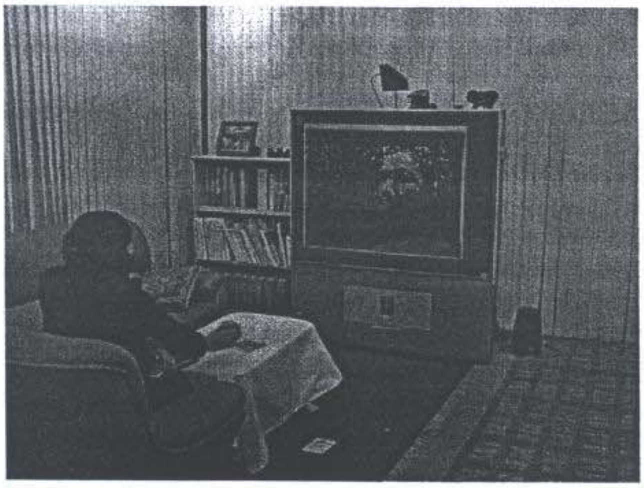


Fig. 4. Set up in ubiHome

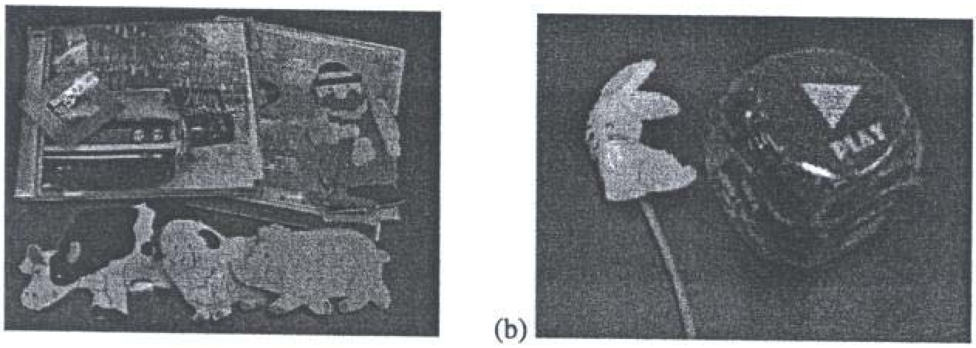
(a) (b)


Fig. 5. Tangible Object (a) Media object (b) Control object

other kind of tangible objects, can be implemented in two ways; an RFID-enabled object and a tracker-embedded object. An RFID-enabled object attaches an RFID tag, which contains control state information, and a picture to each side of cube. The picture depicts control state information contained in the RFID-tag on opposite side of cube. Through the attached picture, users can easily know and select a control command. Additionally, as soon as a user puts the RFID-enabled object, with a picture representing the desired command, onto the table, the related control function is executed. A tracker-embedded object is embedded with a tracker to a doll which is easy to use. Thus, a user can manipulate media contents, such as various musical instruments or MIDI sounds, by weaving or rotating the object.

As shown in Figure 6, ubiSensors of the proposed TMCS consist of RF module, Tracker module and ubiKey. RF module is implemented by using RFID system of Texas Instrument (S6000 Reader/Antenna Set R1-K01-320A) and the Tracker module uses ISOTRACK II of Polhemus[11]. In addition, the ubiKey is implemented by exploiting USB Flash Drive 16MB.

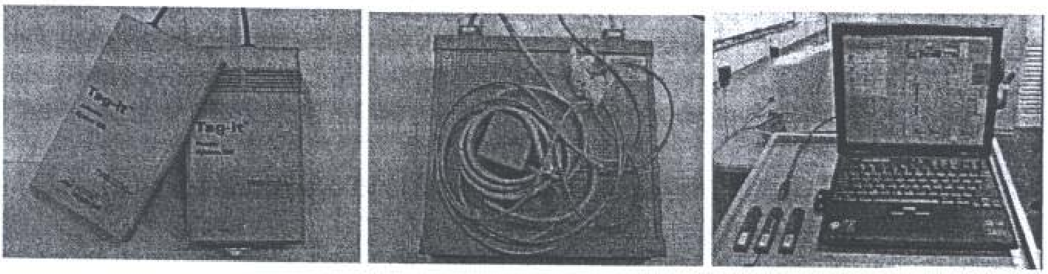


Fig. 6. ubiSensors (a)RF module (b)Tracker module (c) ubiKey

As shown in Fig. 7, Media Controller is implemented by using JDK 1.4 and JMF (Java Media Framework)[12] 2.1.1. Thus it supports various formats of digital media contents (e.g. wav, avi, mpeg, qt, etc) and MIDI. In addition, a Compag ML 370 Server (Pentium III 1G, Dual/IGB DRAM) manages media contents and MS-SQL 2000 Server is used as database to store information related to media contents.

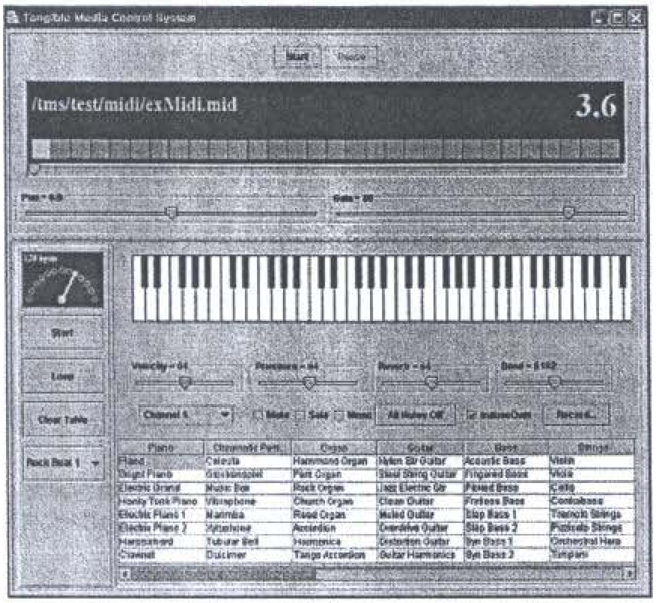


Fig. 7. Media Controller

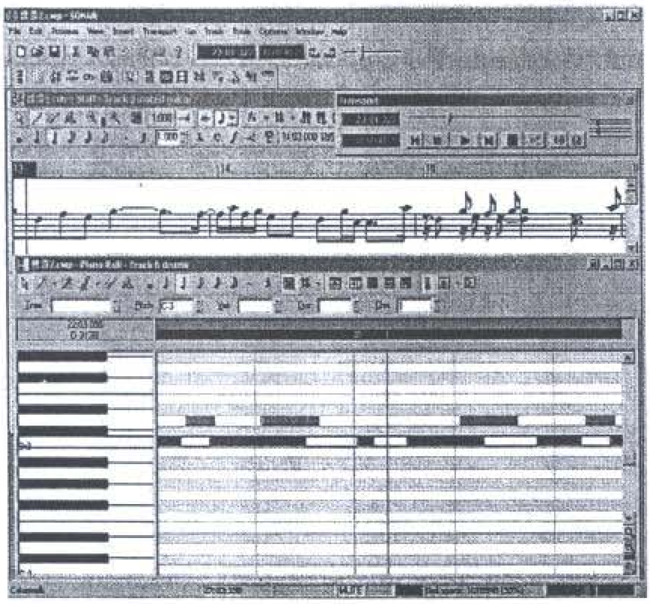


Fig. 8. SONAR

4 Experiments and Results

To evaluate usefulness of the proposed system, we compared the TUI-based TMCS with the GUI-based SONAR [13]. As shown in Fig. 8, SONAR is a MIDI Synthesizer that needs mouse and keyboard for retrieving digital media contents, and selecting or playing musical instruments. In order to ensure an unbiased comparison between TMCS and SONAR, subjects used both two systems in ubiHome. Then, we performed qualitative and quantitative comparison between the two systems. 20 subjects participated in this experiment. One half (group A) of the subjects were in fifties, and not familiar with computers, while the other half (group B) were in twenties, with a good knowledge of computers. Though the number of subjects is not sufficient, we believe that evaluation results show a tendency at least.

4.1 The Qualitative Comparison

To qualitatively compare the TMCS with the SONAR, 20 subjects used each system and then we surveyed their satisfaction over the range from 0% (dissatisfaction) to 100% (satisfaction). It showed how much subjects were satisfied with the control method, media contents and services provided by each system. Table 2 shows the satisfaction for TMCS and SONAR.

Table 2. The satisfaction for TMCS and SONAR

	Elder group (A)		Younger group (B)	
	SONAR	TMCS	SONAR	TMCS
Control	29.5 %	84.5 %	68.5 %	74.5 %
Contents	68.0 %	83.5 %	70.0 %	75.0 %
Service	58.0 %	75.0 %	73.0 %	76.0 %

Since most subjects of Group 'A' were not familiar with computers, they faced difficulties in controlling digital media contents by using mouse and keyboard. Thus they showed low satisfaction (29.5%) for control method of SONAR. However, they expressed high satisfaction (84.5%) towards TMCS because they could naturally move their hands to control media contents with tangible objects. In addition, they expressed more satisfaction for TMCS (83.5%) than for SONAR (68%) since it provides different media contents according to their taste. Though two systems allow subjects to synthesize several media contents or modify the media contents, they were more satisfied with TMCS (75%) than with SONAR (58%). Therefore, through the results of group 'A', we found that they used tangible objects more easily than mouse and keyboard, and showed more satisfaction for TUI-based TMCS than GUI-based SONAR.

In case of Group 'B', younger subjects showed higher satisfaction about control method for TMCS (74.5%) than for SONAR (68.5%). This is because TMCS allows subjects to intuitively access media contents by using tangible objects without any information of the media contents. As group 'A', they were also more satisfied with the personalized contents provided by TMCS (75%) than contents of SONAR (70%). They showed slightly higher satisfaction for those services offered by TMCS (76%) than provided by SONAR (73%). Especially, they expressed higher contentment for natural interaction through tangible object when they manipulated media contents by using both systems.

As a result, subjects generally showed more satisfaction for the proposed TUI-based TMCS than for GUI-based SONAR. Most subjects were satisfied that they could naturally manipulate digital media contents by using tangible objects. They also expressed high satisfaction about providing personalized adaptive contents according to their taste and preference.

4.2 The Quantitative Comparison

To quantitatively compare the TMCS with SONAR, we measured learning time, selection time and control time. Learning time was the time taken by 20 subjects to learn how to use each system. Selection time was the time spent while selecting media contents. It was measured until digital media contents were actually displayed on a monitor or a TV. We also measured control time to manipulate keyboard and mouse or control objects for controlling digital media contents. Table 3 shows the average of each time for TMCS and SONAR.

Table 3. The learning /selection /control time for TMCS and SONAR

	Elder group (A)		Younger Group (B)	
	SONAR	TMCS	SONAR	TMCS
Learning time	801 sec	369 sec	100 sec	36 sec
Selection time	366.7sec	4.1 sec	25.6 sec	3.4 sec
Control time	99.4 sec	2.1 sec	2.0 sec	1.6 sec

As shown in Table 3, group 'A' took more than 13 minutes (801 seconds) to learn how to use SONAR. On the other hand, it took those about 6 minutes (369 seconds) to know how to use TMCS. Additionally, since most subjects of group 'A' made repeated mistakes while using keyboard and mouse, it took them more than 6 minutes (366.7 seconds) to select digital media contents. They also spent about 99 seconds to control digital media contents. In case of TMCS, since subjects could select digital media contents only by placing media objects onto a table, it took those about 4 seconds to do the task. They also spent about 2 seconds to manipulate digital media contents by using the control object. Through these results, we found that the proposed TMCS provides an effective interface to those who are not familiar with keyboard or mouse, such as the subjects of group 'A'.

In case of Group 'B', younger subjects took about 100 seconds to learn how to use SONAR. As shown in Table 3, their learning period for TMCS (26.5seconds) was much shorter than that for SONAR. Though most subjects of Group 'B' were familiar with computer, selection time for SONAR (36 seconds) was longer than that for TMCS (3.4 seconds). This was because they had to input URL of digital media contents with keyboard or mouse. However, there is little difference between control times of both systems, so the subjects did not observe much variation.

Therefore, the proposed TMCS offered more efficient methods for selecting and controlling digital media contents than SONAR. Most subjects spent less time to select and control media contents with TMCS than with SONAR. This is because TMCS allows subjects to easily access digital media contents without knowing URL of the media contents. By comparing learning times, we conclude that was easier to learn how to use TMCS than SONAR.

5 Conclusions

The proposed TMCS provides a TUI-based interface by using tangible objects such as CD, picture, doll, etc. Accordingly, the TMCS provides a convenient and an intuitive interface for users to easily access and manipulate digital media contents in smart home environment. It offers personalized contents to a user by utilizing contexts of both a user and his or her environment .The proposed system also provides an interactive environment in which users can manipulate digital media contents according to the their taste. Thus, the proposed system can be applied to various applications such as interactive education, entertainment and media editor. For the future works, we have a plan to do further qualitative analysis with more subjects, and then to improve the current design of tangible objects. Moreover, we intend to make "container" object which will enable users to store and carry the media contents.

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