Adjustable Interactive Rings for iDTV: First Results of an Experiment with End-Users

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Abstract. Based on previous results of our research in the field of physical artifacts for interaction with Interactive Digital Television (iDTV) we developed a new digital device we named Adjustable Interactive Rings (AIRs). This work presents a quantitative analysis of an experiment conducted with twelve end-users in order to investigate the interaction of users with the hardware prototype of AIRs for iDTV. The experiment results presented in this paper indicate a positive acceptance of our solution and a good learning curve with respect to the interaction language of this physical artifact of interaction.

Keywords: interactive digital television, interaction design, user experiment, quantitative analysis, gesture-based interaction, human-computer interaction.

1 Introduction

Literature indicates that the remote control, the main physical artifact of interaction with the television system, is not appropriate for mediating the interaction between users and applications of Interactive Digital Television (iDTV), especially in a scenario of diversity of user profiles.

Based on results we already obtained conducting research in the domain of physical artifacts of interaction for iDTV with a Human-Computer Interaction (HCI) perspective [4,5,6,7,8,9,10], this paper presents quantitative results of an experiment with end-users aiming at the evaluation of the interaction enabled by the hardware prototype of the Adjustable Interactive Rings (AIRs). AIRs for iDTV is a technology resulting from a research project [11] conducted to develop a hardware alternative for the context of iDTV use, overcoming the many barriers of interaction that current remote controls present, as discussed by various authors, e.g. [1,2,3,5,12].

This paper is organized as follows: Section 2 presents the Adjustable Interactive Rings for iDTV; Section 3 describes the scenario and the methodology of the experiment; Section 4 presents the activity results and discusses these results under a quantitative perspective; Section 5 presents concluding remarks and indicates future work.

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2 Adjustable Interactive Rings for iDTV

Based on the understanding that a more direct interaction with iDTV requires the physical artifact of interaction to be more transparent to the user, i.e., that the focus should be at the interactive applications interface and not at the artifact itself, we designed and developed a patent-pending physical artifact of interaction for iDTV called Adjustable Interactive Rings (AIRs).

The design solution was informed by the principles of Universal Design [14] and developed in a participatory approach [13] with representatives of the target audience. The resulting physical artifact of interaction, as specified and implemented in [6], is accessible, adjustable, ergonomic, and ambidextrous. It also enables flexible use and has a simple gesture-based interaction language for use by all people, to the greatest extent possible. This new digital artifact has two parts: i) the physical artifacts that enable interaction between the users and the television system, i.e., a set of three different AIRs; and ii) the device responsible for the capture of gestures made by users that are using the AIRs. This capturing device is called Receiver Interfacing Module (RIM).

This new digital device does not use textual input or output, to provide increased accessibility and enable a wider range of potential users, since a significant portion of the target audience of our research can be characterized by different levels of visual impairment and low literacy. The gesture-based interaction language has been shown easy to learn and allows the AIRs use in arbitrary fingers or not in the fingers at all, in order to maximize its use by people with different levels of motor impairment. Each AIR has only one button. Fig. 1 presents a user using the hardware prototype of AIRs for iDTV.

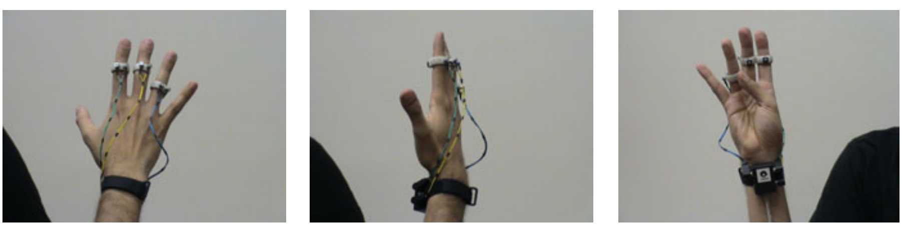

Fig. 1. User using the hardware prototype of AIRs for iDTV

3 Research Scenario and Methodology

The AIRs for iDTV experiment aimed at evaluating the interaction enabled by the hardware prototype of this new digital artifact. Activities started in July 2010 and were recorded in audio and video, with prior consent from users, to facilitate the *a posteriori* analysis of this activity.

Users were grouped in six different pairs, identified below as P1, P2, ..., P5, P6. The initial idea was that for each pair, only one member would in fact use the AIRs to interact with a simulated application of iDTV. Thus, the user not using the AIRs could observe and optionally help the partner in performing the tasks. The decision of who would use the AIRs was made by the users without the intervention of the facilitator of this experiment, the first author of this paper.

The persons who participated in this experiment originally came from different regions of Brazil – South, Southeast, North and Northeast – and showed different levels of experience with the use of technology, ranging from computer instructors to people who had never used a computer before and have trouble using ATMs, mobile phones or other digital artifacts. The 12 participating users are identified by U1, U2, …, U11, U12. Table 1 shows details of these users.

Table 1. Ethnographic data regarding the participants

User	Pair	Age	Gender	Schooling Level	Occupation
U1	P1	23	M	Bachelor's degree	Graduate student
U2	P1	24	M	Master's degree	Graduate student
U3	P2	29	M	Master's degree	Graduate student
U4	P2	35	F	Master's degree	Graduate student
U5	P3	48	M	Bachelor's degree	Economist
U6	P3	48	F	Doctorate degree	Researcher
U7	P4	22	F	Bachelor's degree	IT professional
U8	P4	23	M	Ongoing bachelor's degree	Undergraduate student
U9	P5	57	F	High school	Housekeeper
U10	P5	23	M	Bachelor's degree	Informatics instructor
U11	P6	58	F	Bachelor's degree	Handcrafts woman
U12	P6	56	F	Some high school	Elderly nurse

During the experiment, the six pairs were divided into two groups: i) pairs without prior knowledge about the solution of AIRs for iDTV; and ii) pairs with basic knowledge about the AIRs. Before conducting the actual experiment, the pairs in group (ii) were invited to attend a presentation about the AIRs for iDTV, where the facilitator demonstrated the gesture-based interaction language by showing examples of different AIR functions using non-functional AIR mock-ups. The intent of this approach was to test if a previous exposure to the interaction language had a positive effect on task performance. The pairs who attended this explanation were P1, P4 and P6.

The following materials were used during the conduction of the experiment:

- hardware prototypes of AIRs and RIM;
- mock-ups of AIRs;
- one laptop with RGB output;
- one datashow;
- one table to support the RIM;
- one digital camcorder;
- one stopwatch;
- twelve forms of personal data;
- twelve feedback forms;
- twelve forms of the Self Assessment Manikin (SAM);
- six forms of the observer.

The following six (T)asks were performed during the experiment and presented to (ii) group in this sequence:

- T1: Turn on the television;
- T2: Enter name or nickname;
- T3: Move three geometric figures to their correct positions in the interface one at a time;
- T4: Switch from channel 2 to channel 12; in Campinas (Sao Paulo, Brazil) where the experiment was conducted, these correspond to the channels Rede Record and Rede Globo/EPTV;
- T5: Adjust the volume;
- T6: Turn off the television.
- During the conduction of the experiment, three researchers were present executing the following functions:
- Facilitator: Responsible for conducting the experiment and audio capture;
- Observer: Its function was to fill out the evaluation of tasks, including the marking of time that each user took to accomplish tasks;
- Cameraman: Responsible for the filming the user interaction with the prototype of AIRs for iDTV.

4 Experiment Results

After a brief explanation about how the users would conduct the tasks of the experiment, group (ii), i.e. P1, P4 and P6, assisted a presentation of the gesture-based interaction language with AIRs mock-ups. After this explanation, the second moment included the accomplishment of tasks by users. This explanation was necessary so that all users were aware of what they would do. However, it is noteworthy that the explanation did not teach users how to use the AIRs, except P1, P4 and P6 who, before the experiment, watched a simulation of the interaction language of AIRs through mock-ups. Thereafter, the actual experiment started (cf. Fig. 2).

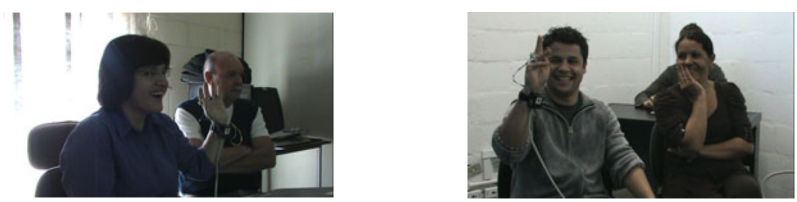

Fig. 2. Experiment moments of AIRs for iDTV

4.1 Quantitative Results

Table 2 shows the time each user required to perform the tasks. As mentioned in Section 3, the initial idea was that only one user of each pair would use the prototype. However, during the activity, all users expressed their wish to use this new digital artifact, hence Table 2 presents the performance of all twelve users.

Table 2. Users vs. Tasks (times in seconds)

User/Task	T1	T2	T3	T4	T5	T6
U1	2.00	79.55	31.79	17.75	9.62	2.00
U2	2.00	108.85	19.42	24.54	43.25	5.28
U3	13.62	16.07	9.06	60.08	18.19	18.81
U4	264.63	36.37	19.56	3.41	4.67	22.03
U5	2.00	113.56	29.50	83.42	103.12	2.00
U6	70.13	381.84	27.82	38.03	55.50	2.00
U7	2.00	101.78	10.07	n/a	n/a	2.00
U8	10.37	79.50	84.07	46.72	4.72	18.04
U9	17.08	82.75	105.06	8.28	2.34	16.88
U10 (1st)	111.81	166.49	93.28	34.44	88.41	4.09
U10 (2nd)	2.35	35.56	42.56	54.53	54.81	2.00
U11	4.83	691.32	80.18	76.66	109.84	16.93
U12	25.16	640.88	n/a	n/a	n/a	n/a
Average	**40.61**	**194.96**	**46.03**	**40.71**	**44.95**	**9.34**

Fig. 3 presents a chart that summarizes the data of Table 2. Regarding the exact two seconds that some users required to carry out T1 or T6, according to the interaction language, in order to turn the TV on or off, the button of a certain AIR had to be pressed for 2s. Thus, two seconds for T1 or T6 mean optimal task performance.

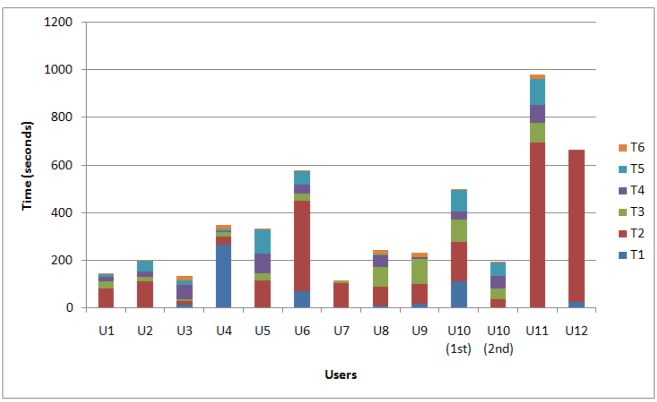

Fig. 3. Time required by each user to perform the tasks

4.2 Quantitative Analysis

The following is an analysis of this experiment using the quantitative data (i.e. task performance time) as a point of reference for our considerations about user interaction with the prototype. In the case of P1, U2 was the first user to accomplish the tasks, followed by U1. As can be seen in Fig. 4, U1 performed most tasks more efficiently than the U2. Regarding the worse performance of U1 in the realization of T3, we observed a minor problem of the prototype hardware during task performance regarding the accuracy of the electronic sensor that captures the AIR movement.

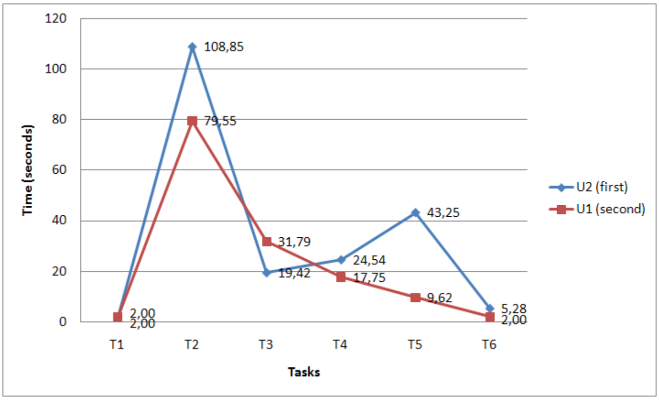

Fig. 4. Time P1 required accomplishing the tasks

In the case of P2, U4 was the first user to accomplish tasks and U3 was second. As can be seen in Fig. 5, U3 performed most tasks more efficiently than U4, except for T4 and T5. However, analyzing the video and data collected by the observer, we realized that U4 completed these two tasks "by chance", i.e. without actually knowing the necessary gestures and without being able to explain how she did it. Moreover, the performance of U3 regarding T4 was hampered by the low accuracy of the electronic sensor that captures the movements of the AIRs.

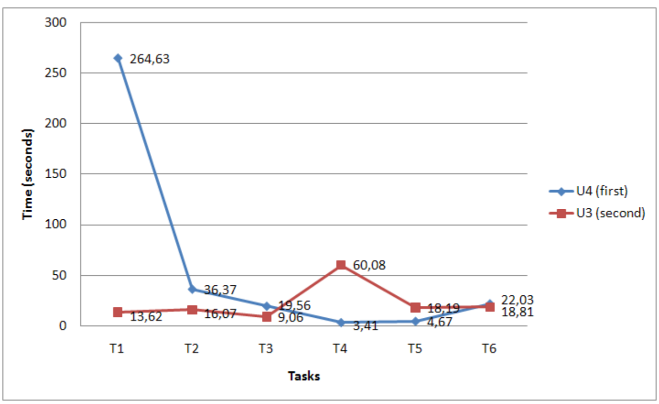

Fig. 5. Time P2 required to accomplish the tasks

In the case of the P3, U6 was the first user to participate in the experiment, followed by U5. As can be seen in Fig. 6, U5 performed most tasks more efficiently than U6. Similarly to the interaction of P2, in the case of this pair, U6 performed T4 and T5 more efficiently than U5. However, reviewing the video of the experiment we perceived that U6 did not knew how to accomplish these tasks. Furthermore, U5's task performance was less efficient due to this user's desire to make sure to absolutely understand how to perform the task. U5 only finalized the tasks after having completely understood which gestures were required to perform the respective tasks.

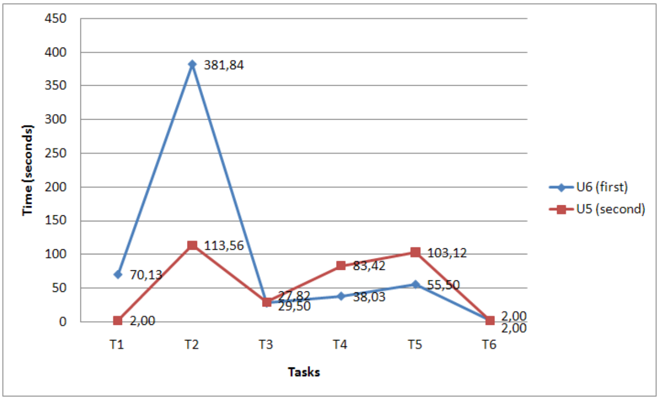

Fig. 6. Time P3 required to accomplish the tasks

In the case of P4, U8 was the first user to perform the tasks, and U7 the second. As can be seen in Fig. 7, U7 performed most tasks more efficiently than the U8, except for T2 since U7 found it difficult to align the sensor electronics from the AIRs with the RIM. U7 completed T4 and T5, but the respective times were not recorded since the facilitator had to intervene due to a hardware malfunction.

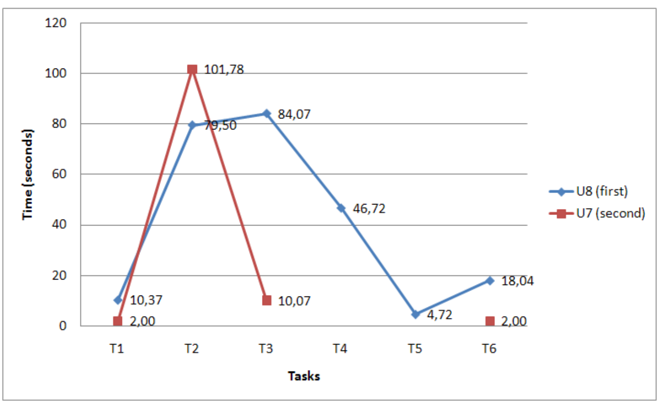

Fig. 7. Time P4 required to accomplish the tasks

In the case of P5, U10 was the first user to participate in the experiment, followed by U9. However, differently from what occurred with the other teams, after U9 having performed the tasks, U10 asked to use the AIRs once more again, and the facilitator authorized the interaction. As can be seen in Fig. 8, U9 performed most tasks more efficiently than U10 during the first iteration. Moreover, it is noteworthy that the second interaction of U10 was more efficient than the first iteration.

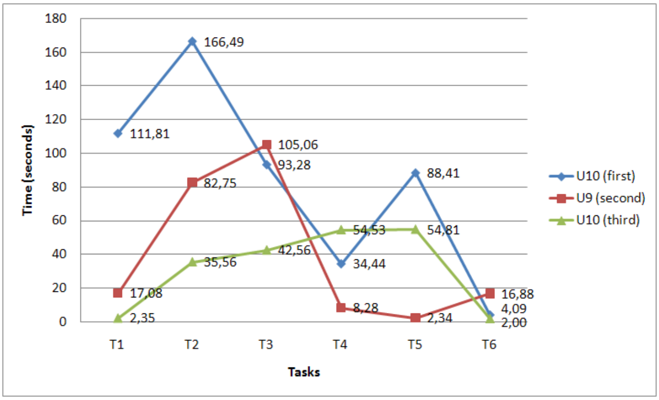

Fig. 8. Time P5 required to accomplish the tasks

In the case of the P6, U12 was the first user to accomplish tasks, followed by U11. As can be seen in Fig. 9, U12 completed only the first two tasks. After that, she experienced a discomfort in the arms and decided not to proceed with the experiment. Perhaps discomfort is related to the long time interval of approximately 640s during which the user remained with the hand facing the television to conclude T2. We understand that T1 was executed more efficiently by U11 than by U12, due to U11 having observed U12 performing the first experiment.

Differently from the other five pairs, during the performance of T2, U11 and U12 required a very long time to complete this task – more than three times the average task performance time – because of the difficulty of these users to align the RIM's electronic sensor that captures the movements of the AIRs. An important fact, which may explain this difficulty is, that U11 and U12 are not familiar with the use of technology in their daily lives.

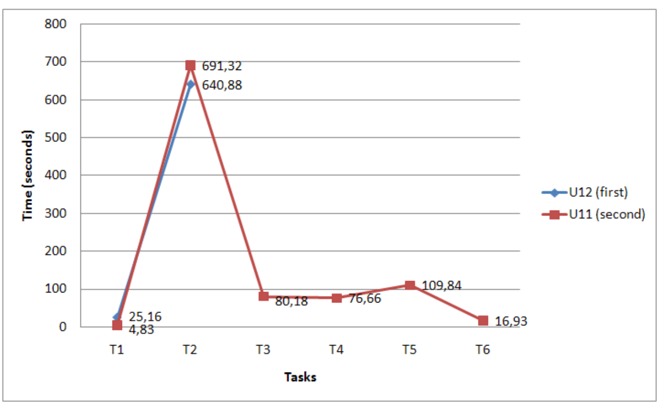

Fig. 9. Time P6 required to accomplish the tasks

Based on the six pairs' measured task performance times, we observe a tendency of the second user to perform tasks more efficiently than the first one. We understand that this is due to rapidly learning the AIR interaction language by merely observing others using the AIRs. This can be corroborated by a comment by U10 during the interaction of U9. U10 said: "You were much faster" and U9 replied: "But I saw you using [the AIRs]".

We conjecture that in some of the cases in which the time to perform a particular task by the second user was less efficient than that of the first, this was due to problems related to the accuracy of the electronic sensor that captures the movement of the AIRs, and not due to a lack of understanding of the interaction language. Although some of the measured task completion times appear to be high, 10 of 12 users completed all tasks. Another positive aspect of the experiment is that all users and not only one of each pair expressed their desire to use the AIRs, which indicates a positive acceptance of this new digital artifact.

Finally, we conclude that the learning curve of the interaction language of AIRs for iDTV was satisfactory, regardless of whether or not users had a prior knowledge of the AIR interaction language. It is worth noting that, like for every new technology or form of interaction, there is always a need for prior training and adaptation to the pattern of interaction. As presented and discussed in this section, adapting to the interaction language of the AIRs for iDTV showed to be a fast process.

5 Conclusion

This paper presented the first results of an experiment conducted with end users to evaluate the interaction enabled by the hardware prototype of Adjustable Interactive Rings. In this experiment participants were asked to perform six tasks regarding the interaction with a simulated iDTV application using AIRs as physical artifact of interaction.

This experiment allowed us to investigate the use of the solution directly with the target audience, including users with little or no knowledge about how to use the AIRs for interacting with iDTV applications. The feedback on how these users perceive and make use of this new digital artifact indicates that users can learn to use the AIRs after only few interactions.

The dissemination of the results of our experiment enables other researchers to work with AIRs, for example customizing the device for employing it in areas other than iDTV, e.g. immersive virtual environments, electronic games, etc. As future work we propose to carry out a qualitative analysis of this experiment focusing on the identification of affective and emotional states of users while using the AIRs for iDTV.

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