An Adaptable Card Game for Older Users

Michalis Foukarakis\textsuperscript{1} Asterios Leonidis\textsuperscript{1} Ilia Adami\textsuperscript{1} Margherita Antonia\textsuperscript{1} Constantine Stephanidis\textsuperscript{1,2}

\textsuperscript{1}Institute of Computer Science Foundation for Research and Technology - Hellas (FORTH), Heraklion, Crete, GR-70013 Greece
\texttt{cs@ics.forth.gr}

\textsuperscript{2}Department of Computer Science University of Crete, Greece

\section*{ABSTRACT}
This paper describes the design and development of an adaptive multiplayer digital card game targeted to the aging population. The game is based on the popular Poker card game “Five Card Draw” and contains a self-adaptive mechanism for rendering its user interface (UI) according to individual user requirements. The game also embeds social interaction elements. The paper presents the tools developed for implementing the self-adaptive mechanism, and describes the UI design process and requirements, the prototyping process, as well as the final implementation and use of the game.

\section*{Categories and Subject Descriptors}
H.5.2 [Information Interfaces and Presentation]: User Interfaces – user-centered design, prototyping.

\section*{General Terms}
Design, Human Factors.

\section*{Keywords}
Digital game design, UI adaptation, prototyping, older users.

\section*{1. INTRODUCTION}
The increasing number of aging people in Europe and worldwide raises concern about their welfare and quality of life.

An important aspect of life at a senior age is to feel socially active and independent. Social relationships and activities are key elements in the quality of life of older people. Information and Communication Technologies and the Internet have a significant potential to help a large number of older users to connect with the outside world and socialize. Entertainment activities can also contribute to socialization for older people and relieve from stress. However, so far the gaming industry has invested millions in designing modern video games for young users, and there seems to be limited availability of games targeted to the older population.

The purpose of designing accessible and fun computer games for older people is to provide recreational means to a highly demanding target group, not familiar with computer technology. Since a high percentage of older users face a decrease of their functional abilities, including accessibility features in computer games is a desirable feature. Another relevant issue is that keeping the mind and brain active throughout life is imperative for older people, allowing the individual to learn, enhance skills and knowledge and to interact with others. This can be achieved through games that challenge the players’ cognitive skills. Finally, to prevent social exclusion, the developed games also need to promote social interaction between elderly people and their friends and family.

Choosing appropriate games for these purposes involves taking into account the needs of the older target population and their preferences. Adapting modern video games for the needs of older people is not suitable, because these games are designed specifically for younger audiences and rarely address older players [1]. Some features of these games should be avoided when designing for older users, such as high frame rate and the need for rapid interaction and reflexes. Moreover, older people usually do not have a high attention span and are discouraged by games which require high learning curves or have complex interactions and controls. Suitable games should be educational, simple to play and enjoyable by all ages, so as to allow younger users to participate with the older relatives.

Another challenge when designing games for older people is that they are likely to have functional limitations due to age, such as loss of memory, lower cognitive and/or motor function, vision impairments, etc. Special care should be taken when addressing these accessibility issues, so as to facilitate both the older end-users who will use the software and the developers who will need to implement accessibility solutions. User interface adaptation according to users’ characteristics is key to address this compelling need.

This paper proposes a Poker-based card game designed for older users and exhibiting a self-adaptive UI. The game, which has been developed in the context of the FP7-ICT Project OASIS\textsuperscript{1}, is meant to be played by both older and young people over the network, and includes social interaction functionality by communicating through a social interaction platform. The user interface has been built by means of a user interface library of adaptive widgets, which supports the seamless embedding of adaptations and accessibility features in UI development.

The paper is organized as follows. Section 2 describes some background work related to games for older people and adaptive interfaces, section 3 describes the Poker game rules and its

\textsuperscript{1} OASIS targets to utilize ICT and other key technologies in order to provide holistic services to older people to support their physical and psychological independence, stimulate their social or psychological engagement and foster their emotional well being. In doing so, OASIS addresses key areas of their activities, encompassing: independent living and socializing, autonomous mobility, and flexible work-ability.
requirements, section 4 analyzes the design process followed for the game, section 5 presents the adaptive widget library and section 6 describes the game software. Finally, section 7 concludes the paper.

2. BACKGROUND WORK

It has already been established in the related literature that the older people are an active gaming population that has specific preferences and expectations from the games they play [1] [13]. The small survey conducted by Copier [2] showed that older adults are familiar with and play computer games from all genres, but are attracted to more traditional games. Two focus groups and four contextual inquiries were conducted by Nap et al. [12] in which it was also made clear that casual games are very popular among the elderly. The same researchers additionally stress the importance, therapeutic value and positive potential of digital gaming in the elderly population [5]. The above observations are confirmed in the study by De Schutter [3], which concludes that the meaning of digital games for older stems from the extent to which games are perceived to foster connectedness, cultivate oneself and others, and contribute to society.

Social interaction between of older players among them and with younger people is very important for both groups and is also a dominant reason for playing computer games [16]. Recently, research interest has focussed on the gaming relationships between grandparents and grandchildren. A good number of older people are interested in games because they give them the opportunity to spend time with their grandchildren [18]. In this context, some games have been created to address this special relationship; two examples are Curball [7] and distributed hide-and-seek [19]. This paper proposes a game suitable for a wider variety of ages.

Card games in particular are a very popular among older people, as confirmed by past studies [1] [13]. Therefore, adaptations of card games in digital form are anticipated to be favorably accepted by the aging population, since they are familiar with the concept of playing cards in the physical world. The additional advantage here is the ability to make them playable over the internet so that users can play remotely. However, there are some difficulties in designing these kinds of games for older people. One participant in the focus groups of Nap et al. [12] complained about the size of cards in a Solitaire game and the lack of option to enlarge them. In the work reported here, this issue is addressed by providing adaptations and alternative designs for accessibility, taking into account common impairments brought about by age.

Grammenos et al. [4] have proposed the concept of Universally Accessible Games. In this line of work, adaptation mechanisms are used to achieve accessibility, usability and playability of electronic games for players with different characteristics and abilities. The adopted approach to game adaptation builds on research efforts which have elaborated more comprehensive and systematic methods and tools for user interface adaptations in the context of Universal Access and Design for All. The Unified User Interfaces methodology was conceived and applied [17] as a vehicle to efficiently and effectively ensure, through an adaptation-based approach, the accessibility and usability of UIs to users with diverse characteristics, supporting also technological platform independence, metaphor independence and user-profile independence. The adaptable widget library used to develop Five Card Draw is also based on the background of Unified User Interfaces [8].

3. GAME RULES AND REQUIREMENTS

Five Card Draw is a popular card game for all ages, and its strength mainly lies in its simplicity. Having a game that is adaptable for use by all ages decreases the chances that elderly people feel socially isolated, since they will be able to play with their friends as well as with younger members of the family.

3.1 Game Rules

In Five Card Draw Poker, classic rules for poker hand strengths are in effect [11]. A poker match consists of a minimum of 2 players and a maximum of 4. The players enter the game with an amount of chips, which is the game’s currency. The winner of the match is the player that has earned all the chips from the other players. The match is divided into rounds, and in each round the players participate by betting an amount from their chip stack or opt not to participate by “folding” their hand of cards. The round consists of four phases, a betting phase, a discard phase, a second betting phase and a showdown phase.

Each player starts the round with five cards that form one of poker’s hand combinations and bets a predetermined amount of chips, called ante. The goal of each player is to maximize the strength of his or her hand and win the most chips from his or her opponents. The players act in turn.

In each betting round, if no one has betted anything, the active player can bet an amount of chips or check (pass the turn without betting). If someone has betted before the active player, the latter can choose to call the bet (bet exactly as much as the previous bet), to raise (bet more chips than the previous bet) or to fold (stay off this round and lose all the currently betted chips). If a player desires or does not have enough chips to call the previous bet, the all-in option is available (bet all the owned chips). The betting process continues until all remaining players in the round have betted the same amount of chips, or all but one have folded. If there are two or more players in the round after the first betting phase, the discard phase follows.

In the discard phase, each player has the choice to discard up to five cards from hand and replace them with the same number of cards, in order to improve the strength of the poker combination in hand. The number of cards discarded is known to other players, so that they can adapt their strategy accordingly (for example, a player who discards 5 cards will get a random hand back, while a player who discards just one probably has a strong hand already).

After the discard phase, a second betting phase follows, where the same rules apply. Following this phase, the players who haven’t folded reveal their hand of cards. This is called showdown. The player with the greatest hand combination wins all the betted chips. If there is a tie, the chips are divided. Also, a player who has bet all of his or her chips cannot win more from the other players than the amount already betted. In that case, the rest of the chips are divided between the other players according to their hand strengths.

3.2 Design Requirements

To make the game attractive to older users a number of design requirements were identified. Textual information had to be displayed in a clear concise manner and graphical cues about whose turn it was to play or, what action was expected by the user at any given moment, had to be provided without overwhelming the user. Given that many things happen simultaneously during the game, these were definitely not easy tasks to achieve. The game play screen needed to have six different components, in order to provide the required functionalities: (a) the game table, where all the action takes place, (b) the card area, where the
player’s cards are shown along with information about them (how potent the combination, which to discard, help, etc.), (c) the betting controls, where the player has the choice of what to bet or skip the current round, (d) the game status area, where information about what is happening in the game is displayed, (e) the chat area, where the conversations between the players are displayed and the ability to send a message is offered and finally (f) the rest of the game options, such as leaving the game or viewing help. User Interface adaptation according to the older users’ characteristics and needs was considered of fundamental importance in order to support the game accessibility and usability by the target user population. Finally, it was particularly important for the game to support social communication in order for the older users to be facilitated in initiating games, finding co-players and enjoying enhanced social contacts through playing.

4. DESIGN AND EVALUATION PROCESS
The user interface design followed the typical multiple-stage iterative design process of prototyping, evaluating, analyzing, refining, and evaluating again. Taking into account the requirements stated in the previous section, preliminary non-working screen mockups were built that demonstrated what each of the six user interface components would look like (see Figure 1). These mockups were evaluated by user interface experts against usability and accessibility standards. The mockups were then revised based on the findings of the experts’ evaluation and a paper prototype version was built for further testing with real potential users. The actual coding implementation of the game didn’t start until after both evaluation rounds and the revisions were finished.

4.1 Expert Evaluation
As mentioned in the previous section, the preliminary GUI design was first evaluated by two user interface experts against usability standards and accessibility guidelines. Each expert produced a report which identified the potentially problematic areas and offered recommendations on how to eliminate them and how to improve the overall flow and presentation of the game. The experts expressed concern over a few design elements that they thought would present difficulties to users and especially older users. For example, the sliding betting bar is not easy to use by someone who has trembling hands or other motor impairments. Also, someone with poor eyesight might have trouble reading the information that was overlaid on the betting table. The designers revised the preliminary mockups based on the findings of the experts’ evaluation and the process was repeated until most major usability and accessibility problems were resolved and the interface was improved to a degree that was rendered suitable for further testing with real users.

4.2 User Evaluation with Paper Prototypes
Paper prototyping was chosen as the method for testing with real users because it doesn’t take a significant amount of time to set up and yet it can easily simulate, by using paper equivalents to a graphical user interface, all the possible UI responses to user actions, such as pressing buttons, scrolling, etc. (Figure 2).

Ten people were chosen to participate in the paper prototype evaluation, four males and six females. All of them had prior computer experience, but four had never played Poker before either online or offline. The evaluation sessions took place inside an office room and were videotaped by one camera. During the evaluation there were two evaluators present, one for changing the paper interfaces according to the user’s actions and one for taking notes and assisting. The testers were given general instructions on what the game was about and how it was played, but not on how to perform the specific game related activities. The goal was to observe if the prototype graphical user interface (GUI) was intuitive enough so that users would perform the desired action without any external help.

It was decided that no older users were going to be included in this evaluation round because the interface was still at a very early stage of development. It is, however, in the future plans to test a working game prototype with older users.

4.3 Paper Prototype Evaluation Results
The paper prototype evaluation proved to be very helpful and insightful because not only it managed to uncover some design elements that were confusing to the users, but also managed to identify functionality that was missing or was presented in a not intuitive way. For example, a few users commented on the fact that there should be a “keep all” button for the case scenario where the user did not want to discard any of his cards, That functionality was actually present in the prototype, but it was presented in a way that was not clear to the user. The user had to press the “discard” button without selecting any of the cards in order to keep them all, but that proved to be counterintuitive as none of the users thought of doing so. A few other design changes resulted from the comments made by the users. For example, some users pointed out that it would be helpful to them if the dollar amount of their bet also appeared on the table area next to their chips instead of just next to the betting buttons. Others had
4.4 Final UI Designs

The final designs were used as a basis for implementing the application. The six different areas of the screen were organised as follows (see Figure 3): (a) The game table was positioned on the top left side, since it is the biggest area and the user needs to be focused there when it’s not his or her turn. (b) The card area was positioned directly below, because the players need to constantly check their cards along with what is happening on the table. (c) The betting controls were positioned below the cards area and become visible only when the player has to use them. The remaining game areas, the (d) game status, the (e) chat area and the (f) rest of the game options were situated on the right side of the screen from top to bottom so as not to interfere with the game action.

The subsequent step was to create an online prototype using the adaptive widget library described in the next section, integrated in the popular NetBeans Integrated Design Environment, in order for the implemented interfaces of the game to seamlessly exhibit adaptations suitable for the target user group of older people.

5. ADAPTIVE WIDGET LIBRARY

User Interface experts face a great challenge when designing application GUIs for the elderly, as they must address the requirements stemming not only from the diverse characteristics of this population segment, such as vision impairments and senile dementia, but also from their unfamiliarity with technology. The latter, combined with the variety of potential target devices (i.e., PCs, tablet computers, handheld devices etc.), further complicates the designers’ task, and the need for tools that facilitate the design by inherently supporting adaptation becomes imperative. Also in the case of the Five Card Draw, UI adaptations were considered as necessary to increase the accessibility and usability of the game by the older target user group.

In the context of the OASIS project, an adaptation framework was developed for building accessible user interfaces for older users, supporting: (i) the automatic adaptation [14] of various user interface aspects according to the individual profile of each older user and (ii) the encapsulation of such adaptation-based accessibility features in a development toolkit in a transparent way, in order to facilitate their utilization by the developers.

On the one hand, from a conceptual point of view, this framework supports alternative designs and guidelines produced by UI experts according to specific user and context requirements [8] [9]. On the other hand, the framework offers a practical solution for the developers by ensuring:

- maintainability (single point modification automatically affects the entire system without the need of further manual propagation)
- scalability (extension support through plug-ins)
- usability (decision-making complexity and adaptation mechanism are encapsulated inside every widget).

The UIs of the Five Card Draw game have been developed using this framework as a case study towards assessing its usefulness for designers and developers, as well as the added value of the provided UI adaptations for end-users.

5.1 Architecture

The Adaptation Framework consists of (i) the adaptation decision making component and (ii) the Adaptive Widget Library. The adaptation decision making component is based on the rule-based Decision Making Specification Language (DMSL [14]) and includes the DMSL Core and the DMSL Connector, while the library includes enhanced, adaptation-aware instances of common widgets.

The DMSL Core is responsible for loading and evaluating the adaptation rules, whilst in order to provide an efficient server implementation that could serve multiple clients simultaneously, the core provides inherent support for making multiple decisions simultaneously for different clients, as each client contains its own private engine instance responsible for its own evaluation requests. The other half of the decision making component, the DMSL Connector, acts as a mediator between the core and external “clients”, by monitoring incoming connections, processing the requests and invoking the appropriate core methods. For that to be achieved, appropriate structures are provided to associate a remote client with a unique engine instance, and encapsulate all communication related features (i.e., the Connector is responsible for sending the appropriate messages, receiving and parsing the corresponding responses so as to supply the library with the appropriate data).

The Adaptable Widget Library contains a set of adaptation-aware UI components designed to satisfy the needs of different target device – Swing-based components for PC, AWT-based components for Windows Mobile devices. Each widget in the Adaptable Widget Library inherently supports adaptation in a way transparent to developers, who can use them as “traditional” UI building blocks. The implemented adaptations are meant to address the interaction needs of older users, and follow specific guidelines which have been encoded into DMSL rules [10].

This approach is targeted to novice developers of adaptable user interfaces. The Adaptable Widget Library is the solution proposed to relieve developers from the task of re-implementing or modifying their applications to integrate adaptation-related functionality. For that to be achieved, each widget encloses a list of adaptation attributes and when instructed to adapt itself (automatically by the system), it evaluates each attribute and applies the corresponding decision(s).
The developed widgets are built in a modular way that facilitates their further evolution, by offering the necessary mechanism to support new features addition and modifications. Therefore, more experienced developers can use their own adaptation rules to modify the adaptation behavior of the interactive widgets.

Finally, considering that the DMSL Core can be a remote component, network connectivity is an essential precondition for the overall process. To address this issue, a fail-safe mechanism has been developed to minimize the side effects of potential connectivity loss, where the “last” known configuration is stored and maintained locally to facilitate “static” user interface generation without supporting on-the-fly adaptation.

5.2 Prototyping adaptable UIs
In order to facilitate the employment of the Adaptation Framework approach into real life applications towards rapid development of adaptable UIs, the Adaptable Widget Library has been integrated into the NetBeans GUI Builder. Its integration offered prototyping functionalities such as live “UI” preview at design time, as well as automatic application of specific sizing directives. Moreover, NetBeans facilitates the implementation of the application’s logic associated with the UI, thus offering not only a prototyping tool but a complete framework supporting the entire application development life cycle (design, development and maintenance) from a high-fidelity prototype to a final application.

To prototype a user interface, the designer will create the application’s main window, i.e., a new JFrame Form, and add the common containers (e.g., menu panels, status bar, header) by placing AdaptivePanels where appropriate. To customize widgets, the typical process is to manually set the relevant attributes for each widget using the designer’s “property sheets”. To apply the same adjustment to other widgets, one can either copy/paste them or iteratively set them manually.

In the adaptation-enabled process, using the function attribute, the process is slightly different. First, one needs to set the function attribute, then define the required style (e.g., colors, images, fonts), and finally to define the rule (in a separate rule file) that maps the newly added style to the specific function. Whenever the same style should be applied, it is sufficient to simply set the function attribute respectively (CSS-like).

In some cases, more radical adaptations are required with respect to widget customization, as the same physical UI design cannot be applied “as is”. In these cases, alternative dialogues can be designed by creating a container to host the different screens. For each screen, a JPanel Form is added. The adaptation library offers the means to dynamically load different UI elements on demand, providing the functionality through adaptation rules, and utilizing alternative Java’s mechanisms including (i) suitable layout managers (e.g., CardLayout manager) and (ii) reflection (introspection) capabilities.

6. THE FIVE CARD DRAW GAME
The poker game is composed of two entities, the software itself and a card game ontology.

6.1 Architecture
The software is divided into two separate components: the server and the client. The server is responsible for maintaining the games currently available to join and orchestrating the games that are already in progress, while the client contains the adaptive graphical user interface and is responsible for displaying game information and managing game controls.

In more details, the server maintains a list of created games which the players can join and leave at will. Once the minimum number of players has joined a game, the game starts and each game client is instructed on what to display in each phase, according to the rules of the game. The server also receives and updates players’ statistics such as how many rounds a player has won and what is the best hand of cards that the player has won a round with. Finally, the server communicates with the players’ social profiles and posts relevant status information about their activities during a poker match (such as how many chips the player won etc.).

The client program’s user interface has been built using the adaptive widget library (see Figure 4). Apart from displaying relevant information and functionality during a game, the client is also responsible for transmitting statistics information to the server and creating game related events for inviting friends to future poker matches, through the social platform.

![Image](https://via.placeholder.com/150)

**Figure 4. Instance of the Five Card Draw user interface.**

6.2 Card Game Ontology
A Five Card Draw OWL ontology was constructed for use with the OASIS platform [6]. The ontology contains both generic and poker-related concepts. It includes concepts related to player names and nicknames, various commands that a player can issue (for example “bet 12”), various statistics such as how many games someone has won (generic) or how many chips a player has won (poker-specific), identification concepts (game id, social id), chat messages, comments etc.

OASIS uses the ontology to integrate the poker-related services with a higher level hyper-ontology which ensures interoperability between different web services from the same or different application domains. This way, the ontology is connected with the corresponding web services that the poker server manages and the available operations can be called from within the OASIS framework. Apart from the use of the ontology by the OASIS ontological framework, the ontology concepts are generic enough to be used with other poker or card games if needed.

6.3 Game Adaptations
To make the application suitable for use by elderly people, the adaptive widget library and its capabilities were used extensively throughout the development process. The library itself contains three different visual profiles, providing visual adaptations for three different categories of users. The user interface elements for each profile differ in size, shape and color, according to rules that take into consideration user’s age and health condition. The first profile corresponds to the basic color theme with no particular adaptations. The second profile aims to (i) offer good visibility to users that suffer from light visual impairments and (ii) support
users with limited instability in the upper-limbs by expanding every component’s interactive area. Finally, the third profile offers a color theme based on a “black and yellow” combination to support users suffering from various color vision deficiencies, while the components’ interactive area can be expanded on demand as well. For the Five Card Draw application, an additional visual adaptation was used. The card faces change according to user familiarity with the game and/or preference (see Figure 5).

Figure 5. Alternative visual presentations of cards.

Along with the visual adaptations, a number of functional adaptations were incorporated depending on the level of expertise of the player. The experienced player gets full information about the game state and has full control over the betting process. The game status area shows what is happening in detail, for example, the amount a player betted, how many cards were discarded, etc. The player can review what has happened from the beginning of the match and develop strategies accordingly. The hand strength is shown using a percentage indicator. Finally, when betting, all options are available and the player can bet the exact desired amount of chips. This configuration is suitable for players who wish to play more competitively and already know how to play efficiently.

The casual player is only interested in what happens in the current round, so the game status contains information about the current round only. The hand strength is indicated using descriptive expressions (Very good, Decent, Bad, etc.) instead of actual strength. This configuration is suitable for players who have learned the game and how to use the interface and want to have more options when betting.

The novice player will have the least amount of choices available. When betting, three choices are available: bet/raise a predefined amount, check/call the current bet or fold (see Figure 6). This way, an inexperienced player will not be confused by the complexity of the standard betting options, while still being able to play competitively. The game status area, instead of showing what happens in detail during the round, shows instructions about the current phase. During the discard phase, a hint on what cards should be discarded is shown, and the player just has to press the discard button or make his or her own choice if desired. This configuration is recommended for all new players, especially older players with no past experience of card games, and could potential address mild cognitive limitations (e.g., memory loss).

6.4 Social Aspects

The adaptations described in the previous section ensure that the game can be played by players of different age, expertise and abilities. For example, grandchildren have more familiar technology and the rules of the game will use the adaptations provided for experienced players, while older users or other novice users can use the more light version of the game, which is automatically adapted to suit their needs. Since the game has been designed with multiplayer gaming in mind, the older can choose to play with friends and family over the network.

Another desirable part of social activity for older people is the inclusion of them in social communities. For the OASIS project, a social community platform has been implemented, with which the Five Card Draw application can exchange information. This way, users can request information about their friends (matches played and other achievements in the game) and choose who they want to invite for a game event they will create. Additionally, for each significant action or event during a Five Card Draw match, a status update can be posted to their social platform profile and promote their social life by stimulating discussions with friends and family.

7. CONCLUSIONS & FUTURE WORK

This paper has presented a multiplayer card game targeted for older people, which exhibits adaptation capabilities and has been implemented using a library of adaptable UI widgets. The game was designed using an iterative process which included revisions of UI mockups, expert evaluation and paper prototypes. Social features were included by means of communication with a social community platform and in-game chatting.

The game was implemented in the context of the OASIS social community platform, targeted to fight the social isolation of older people and facilitate new collaborative experiences, as well as allowing them to practice cognitive skills and getting familiar with new Information Society Technologies.

The use of the adaptable widget library developed in OASIS to support the development of user interfaces accessible and usable by older people has been instrumental in equipping the game with adaptations according to users’ abilities and playing expertise. Overall, this development has demonstrated the usefulness of the library and of its integration in the NetBeans development environment towards rapidly and effectively designing and implementing user interface adaptations.

A second expert evaluation is planned on the final working UI prototype, with the involvement of older users.

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9. REFERENCES


