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Dynamic Rules: Towards interactive games intelligence

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ABSTRACT
In respect to a state-of-the-art on intelligent tabletop games, this paper introduces a novel challenge that is the creation of a flexible and interactive tabletop framework in which game rules are re-definable by players at any instant of the game. This article discusses the importance of this aspect in the acceptance and personalization of the game, which is a key feature for the players' social interaction. The article first compares classical physical games with purely digital ones to highlight the key features of each world. Based on those features, the article classifies the current intelligent tabletop frameworks and highlights the unexplored dimensions. Finally, the article proposes a research agenda to build a framework for developing tabletop games supporting the dynamic redefinition of rules.

Categories and Subject Descriptors
H.5.2 [User Interfaces and Presentation]: User Interfaces
H.1.2 [Models and principles]: User/Machine systems
D.2.2 [Software Engineering]: Design tool and techniques

General Terms
Algorithms, Design, Human Factors, Theory.

Keywords
Tangible User Interaction, Tabletop gaming, Interactive Intelligence, Mixed-reality, Games rules flexibility.

1. INTRODUCTION
Tangible User Interfaces (TUIs) have recently shown a high potential for enhancing gaming experience, playful learning and for supporting social interaction and collaboration. TUIs are however only one way to build more general mixed reality games. Mixed reality games, as illustrated in the state-of-the-art of this article, tries to take the best of purely physical games and the best of purely digital games to create an augmented gaming experience. Our intuition is that mixed reality games should go further and aim to create novel paradigms of interaction that are superior to just the sum of the advantages of each world, targeting the synergy of both.

This article reviews existing tabletop games and compares classical tabletop games with digital board games in order to elicit the functionalities that are best in each world: physical versus digital. The aim of this state-of-the-art is to discover what are the challenges of mixed reality intelligent tabletop games, and how to go from augmented reality to a real mixed reality where the natural intelligence of human players and the artificial intelligence of computational assistant can create a synergy and lead to novel interaction paradigms that do not exist neither in the classical physical tabletop games nor in digital board games. The article further focus on rules dynamic reprogramming a feature that exist intrinsically in physical games and the related social interactions, that have disappeared from current mixed reality tabletop games. The article finally proposes a brief research agenda to tackle this research issue.

2. STATE OF THE ART
This state of the art first compares gaming in the physical world to gaming in the digital world exclusively with the goal to elicit the most important features and advantages of both worlds for gaming. The section then reviews the related works, i.e. the existing tabletop intelligent games, and classifies them according to the major functionalities elicited in the first subsection in order to highlight the major challenges to tackle in future developments.

Physical versus Digital games
One of the most important characteristic of classical board games is the face-to-face communication. Players sit around a table and communicate via speech, gesture, mimic and by the manipulation of tangible objects on the game board. The communication around the table is mainly public, and if two players want to share private information, they have to leave the table, informing other players that something is going on, or to correspond via codes hidden in standard communication modalities (facial expressions, speech, etc.). Moreover, in standard classical game, the game rules can be treated as fully flexible objects, house rules can be defined before a game session, properties of object can be re-defined, on the fly winning conditions can be dynamical added during the game by means of the social agreement between players. On the other hand, it is difficult to create new objects, or to redefine the game world. Finally, a drawback of the physical world is the huge amount of pieces and cards to manage, leading to a big amount of mundane tasks (sort of similar pieces, shuffling cards, etc.) and increasing the probability that a piece can be lost, what in certain cases can lead to the impossibility of playing.

In digital games the interaction between players is always mediated by the system and thus the communication can be either public or fully private (secret). Further, the degree of game rules flexibility is fixed by the developer of the game. Most of the time, parameters can be tuned at the beginning of the game session, after what they remain fixed until the end. Complementary to this lack of flexibility on the game rules side, the game board and objects are more flexible in the digital world; the game board can be more detailed and can dynamically change according to the game evolution.

Further, digital games offer some computational supports. For instance, the state of the game can be saved and restored in a future session; the machine can provide tutorials, visual cues and helps to support users in games with complex rules. Finally, mundane tasks are always performed by the system. Another aspect that provides the digital world is the ubiquitous dimension; players can be geographically distributed and communicate via network connections.

Table 1 summarizes the observations made above and groups the discovered key features in four major classes: communication, flexibility, support and game interactions. The set of chosen features is far from being exhaustive but should, in our opinion, embrace the most representative features for each provenance i.e. physical or digital as stressed in the table 1. When the feature is "mixed", its provenance is considered to emerge only from the synergy of both worlds.

Table 1. State-of-the-art tabletop systems: key features and novel challenges.

Features	Physical	Digital	Mixed	Short definitions	*STARS*	*Entertaible*	*TViews*	*TARBoard*	*MERL*
Communication									
Face-to-face	■			Human face-to-face interaction through natural communication channels (e.g. speech, gestures, physical contact, gaze, mimic, tangible interaction, etc.)	+	+	+	+	+
Mediated secret		■		Sharing private information between two or more players where either the content or the communication remains secret (e.g. private chat in on-line games)	+	-	-	-	-
Augmented private face-to-face			■	Two or more players sharing private information or virtual game objects in a fully secret manner (either the content or the communication act is private) without breaking the face-to-face configuration.	+	-	-	-	-
Flexibility									
Predefined rules		■		The set of rules that can be modified is fixed by the game developer and cannot be changed during a game session	+	+	+	+	+
Game rules	■			Rules of the game can be freely and dynamically redefined before and during each game session by the players	-	-	-	-	-
Game board		■		The game board can change dynamically	+	+	+	+	+
Game rules & board			■	The rules of the game can be freely redefined before and during the game. Similarly, the game board can change dynamically, as well as the relationship between rules and game objects (e.g. modifying, adding a object and redefining the related rules).	-	-	-	-	-
Support									
Computational support		■		State save, save/resume of game sessions, support for complex rules (e.g. evaluate complex winning conditions), help, etc.	+	+	+	+/-	+
Mundane tasks	■			Sort of similar pieces, shuffling cards, setting the board, etc.	-	-	-	+	-
Game Interactions									
Ubiquitous, distributed		■		Players could be distributed in space over a network.	-	-	+	-	-
Multimodal		■		The interaction with the game is possible via various modalities (speech command, gesture, gaze, touch, keyboard, mouse, etc.)	+/-	-	-	-	+
Tangible	■			The interaction with the game is done through objects' manipulation.	+	+	+	+	-
Tangible + multimodal			■	Tangible and multimodal interactions are combined and integrated.	-	-	-	-	-

Mixed reality tabletop game-platforms

In recent years, many hybrid board games platform have been proposed (STARS [2,3,4,5,6], Entertaible [9,10], Tviews [7], TARBoard [1], MERL & University of Calgary [8]) aiming at improving the player experience by augmenting the physical world of standard board games with computer capabilities. Table 1 compares these systems, and stresses which functionalities of standard board games have been preserved, which new ones have been brought from the digital world and how, by the mixing of these two worlds, some functionalities are lost or new ones emerge only in the mixed world. In the following list, the major observations are commented, where P, D and M, i.e. respectively Physical, Digital and Mixed, indicates the provenance of the feature:

- *Face-to-face communication (P):* It appears clear that a tabletop configuration is sufficient to preserve the face-to-face communication of classical board games;
- *Mediated secret communication (D):* All the platforms preserve the public and private communication forms in all their variants (implicit or explicit). Only STARS allows the use of other ubiquitous devices (such as PDA's, cellular phones, etc.). This kind of devices allows the exchange of private information or game elements without being suspected by other players (i.e. secret communication);
- *Augmented face-to-face secret communication (M):* In STARS a new form of secret communication between players emerged, that is an augmented secret face-to-face communication. Two or more players can exchange private information or even virtual game object in a fully secret manner, trying at the same time to dissimulate their relationships with mimics and speech;
- *Game rules flexibility (P) vs. predefined rules flexibility (D):* None of the examined platforms achieves the rule flexibility of standard board games. The game rules are fully implemented in the digital world and similarly to standard digital games, only a set of predefined rules can be chosen by the players;
- *Game board flexibility (D):* The game board is digital, either projected or on a LCD screen, thus all the platforms support the game board flexibility, i.e. the board can dynamically evolve;
- *Computational support (D):* All the presented platforms could offer some computational supports, since they embed a virtual representation of the game world and rules;
- *Mundane tasks (P):* The amount of mundane task that have to be performed by the players is directly proportional to the number of physical object used for the games. In most of the platforms (STARS, Tview, Entertaible), the number of object can be chosen as a parameter of the game, for example one can chose to use only pawns representing the players figures, which leads to a minimal amount of mundane tasks. In TARBoard, the player can only interact with the tangible object (tagged cards, etc.), and thus it is impossible to avoid for the players mundane tasks such as for example card shuffling;
- *Ubiquitous, distributed (D):* One of the interesting aspects that emerge in hybrid board games is the opportunity to mix face-to-face interaction between players sitting around a table with the potentials offered by on-line games. Potentially all the platforms can support this modality but only the TViews project implements it;
- *Multimodal game interaction (D, P):* The platform proposed by MERL and University of Calgary support multi-modal interaction. Commands to the game can be given through combined modalities, e.g. pointing (touch screen) and speech. STARS lets the player interact with the game through touch or using some external devices such as PDA. Further, feedbacks can be either visual (public on the table or private on the PDA) or audio (public on loudspeaker or private on headphones);
- *Tangible game interaction (P):* All platforms except MERL support interaction with tangible objects, which are tracked using different techniques (RFID, overhead camera detection, marker-based camera detection, electromagnetic or acoustic signal measurement, etc.);
- *Tangible + multimodal game interaction (M):* For the moment, none of the examined platforms offer the combination of tangible and multimodal interaction techniques. However, in all of them such functionality seems easy to integrate.

3. RESEARCH GOALS & AGENDA

Game rules flexibility

In [6], it is stated that in simple games, such as Backgammon, it might be better not to implement the complete game rules into the digital world. If no computer logic forbids rules' variation, it would be easier for players to modify them in the context of a particular situation, and to develop novel house rules. On the other hand, when the game rules are complex, e.g. the winning condition takes into account many parameters, computational supports would be helpful, which can not be achieved without letting the system be aware of the game rules. These two aspects motivate us to explore the possibility of redefining dynamically the game rules at a high abstraction level.

Dynamic rules redefinition is particularly suited for games that exist in many different variants e.g. the Mancala games (Awele, Awale, Ayo, Ourin, Wari, etc.). Players should be allowed to experiment one variant by simply redefining the corresponding rule before a game session, or even invent a new variant defining a new rule without prior knowledge of the underlying programming language but using a high level user interface.

In our opinion, letting the human natural intelligence and imagination interact in a natural and direct way with the artificial intelligence embedded in the virtual world could create a new synergy and lead to a novel interaction paradigm for games. The player will be able either to play a game in the standard way defined by the game creator either to free her/his imagination and experiment variants or fully novel ideas without being limited by the constraints of the physical world (materials, definition of new elements, etc.) and avoiding the lack of flexibility of the digital board by letting the system be aware of the new rules and of the role of the new objects (virtual and tangible) in a natural way.

An interesting use case could be an interactive test environment for game developers where novel ideas and game mechanics could be dynamically and easily evaluated.

Research Agenda

According to the previously presented state of the art, it becomes apparent that one of the most important features of standard board games, i.e. the high degree of flexibility of the game logic, has to be supported by intelligent tabletop games. Our major objective is to define a general framework in which users can easily and dynamically redefine game rules in a natural way. To achieve this goal we have planned to achieve the following tasks:

1. **Modeling**: Define a model suitable for the description of game logic. The logic can be decomposed in three layers: Game world laws, social laws, game rules. The game world laws take into account the topology and the entities affected by the "physical" laws of the world, which are global laws. The social laws affect the behavior of the players and of the abstract entities of the game; those are dynamic local rules that depends on the history of the game. Game rules control the score, and the winning condition of the game.
2. **Framework**: Design and implement a general game development formalism and framework. Further, our work in this task will target a general design framework helping a game designer in its design process by generating a on the fly test environment.
3. **Toolkit for rapid creation of multimodal and tangible interfaces**: A Toolkit for rapid prototyping of multimodal and tangible interfaces will be created to ease the redefinition of rules and game interactions through natural commands.
4. **Integration and applications**: A simple game (e.g. Awele) where the rules can be easily changed before each game instance will be first implemented. The design of the game will exploit the dynamic changing rules paradigm and the multimodal interaction possible. The challenge of this task is to fusion the framework with the multimodal interaction capabilities.
5. **Assessment and evaluation**: The goal of this task is to experiment our novel framework and interaction paradigms. Assessment will be performed through user evaluations both quantitative and qualitative.

4. CONCLUSION

This article compares classical tabletop games with digital board games in order to elicit the functionalities that are best in each world: physical versus digital. The aim of this state-of-the-art is to discover what are the challenges of mixed reality intelligent tabletop games, and how to go from augmented reality to a real mixed reality where the natural intelligence of human players and the artificial intelligence of computational assistant can create a synergy and lead to novel interaction paradigms that do not exist neither in the classical physical tabletop games nor in digital board games. The article further focus on dynamic redefinition of rules, a feature that exist intrinsically in physical games and the related social interactions, that have disappeared from current mixed reality tabletop games. The article finally proposes a brief research agenda to tackle this research issue.

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