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Player-centered game AI from a flow perspective: Towards a better understanding of past trends and future directions

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ABSTRACT

Player-centered approaches that aim to maximize player enjoyment have been steady, but with poor heuristics that do not rely on any particular theory of entertainment. Certainly, the Theory of Flow is the most referred in the game AI area and, still, it is unclear how to effectively design and implement adaptive game modules or understanding which game features drive players to a flow state. Therefore, in this document we perform a systematic analysis of literature aimed to enhance our knowledge about how to adapt flow heuristics to a video game context. This analysis endows us with the knowledge needed to define a flow framework for game AI. Our framework, FlowAI, describes which modules and what gameplay features can be adapted to design an effective video game intended to facilitate the achievement of flow in players. Furthermore, from our framework standpoint, we identify and review existing work that could be adjusted to foster flow. Our aim with this analysis is to identify current challenges, and motivate new directions in the player-centered research area.

1. Introduction

In the beginning, the Game AI area was primarily focused on using video games as a testbed for artificial intelligence algorithms. Nowadays, there are many approaches that have the goal of maximizing player enjoyment through artificial intelligence techniques [1–4]. All these works can be classified in the player-centered subarea of Game AI [5]. The basic idea of these approaches is to make games reactive to players by adapting key game features, such as: space adaptation, missions, character behaviors and difficulty scaling. While each game feature is different to each other, their adaptation mechanisms share an essential module to create a personalized experience: a player model.

The objectives of a player model are to define the player's preferences – towards specific gameplay features – and guide the adaptivity modules about – how and when – they should react, in order to maximize the player's enjoyment. Despite significant advances in this subject, most of the proposed heuristics to adapt game components are vaguely based on theories of entertainment [6]. This lack of formalism ignores decades of research about user experience in other areas.

The Theory of Flow is a well-established theory of entertainment. This theory focuses on learning which are the precursors and outcomes of the optimal experience called flow [7]. When a subject gets into flow, she experiences an intense level of attention [7]. Also, this subjective state of mind has been described as a deep immersion state [8]. Nevertheless, it is unclear how the concepts of flow and immersion are related to each other [9–11].

There have been many efforts to adapt the flow theory to many contexts, including video games [4,6,12–16]. However, it is still unclear how to effectively design and implement adaptive game modules, or even to discern which game features drive players to a flow state. Nevertheless, there is theoretical and empirical evidence indicating that a perfect balance between the challenge faced by the player and her skills is vital if we want to avoid a short-lived flow experience [9,17,18]. The Dynamic Difficulty Scaling (DDS) subarea, is arguably one of the most studied and yet, it is a field with much room for improvement, from a flow standpoint.

This lack of formalism is natural, due to the immaturity of the research area under analysis. As a first step towards a game AI field with better theoretical foundations, we performed an exhaustive analysis on approaches aimed to adapt flow elements to a video game context. Next, we elaborated our approach towards immersion and how this concept contributes in the design of better flow experiences. These analyses endows us with knowledge to understand which game AI subareas can contribute to foster flow.

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From this basis, we present a flow framework that unifies key elements from preexisting approaches, which are suitable for a game AI context. We structured our framework, FlowAI, as a generic player-centered game. Besides, we detailed the relation between its modules in a functional manner.

Accordingly, from our framework standpoint, we proceed to survey the game AI subareas that can contribute to foster flow. Hence, the survey is separated in three parts: player modeling, dynamic difficulty scaling and immersion. We are focused on learning about current trends and challenges. In addition, we believe this work will motivate new directions in the player-centered research area.

2. Overall approach

First, in Section 3 we give a brief introduction to the Theory of Flow. Here, we introduce the constituent concepts to understand flow and how this concept has evolved over the years. Then, in Section 4 we present an exhaustive analysis on approaches aimed to adapt flow elements to a video game context. Specifically, this comprehensive review is aimed to determine the elements of flow that are particularly appropriate to design player-centered games proposed to foster flow. Also, we identify the main open questions in this area. One of those questions is how the concepts of immersion and flow are related to each other. Thus, in Section 5 we argue our standpoint on flow and immersion.

With this theoretical foundation, we present in Section 6 a flow framework for game AI. This framework, FlowAI, unifies key elements from preexisting approaches that better suit a game AI context. Further, in contrast to others, it is detailed in a lower level of abstraction; with the structure of a generic player-centered game. Because its modules can be interpreted as game AI subareas that can contribute to design better games that facilitate, for all kind of players, getting into a flow state. The major game AI subareas our framework includes are: player modeling, dynamic difficulty scaling and immersion. Therefore, through the lenses of our framework, we proceed to survey these subareas in Sections 7–9 respectively. The format of those sections is shared. First, an overview of the state of the art is given. Then, we criticize current approaches from a flow standpoint. Lastly, we close those sections with a *Section Summary*. In this closure, we specify the main challenges and the most promising directions.

Moreover, papers included in those surveys were found by searching the next terms:

> (“Immersion” OR “flow”) AND (“personalization” OR “player experience modeling” OR “experience-driven” OR “User modeling” OR “player satisfaction” OR “real-time adaptation” OR “player behavior” OR “dynamic difficulty scaling” OR “procedural” OR “generation” OR “entertainment modeling”)

In the following databases: *ACM*, *IEEE*, *ScienceDirect* and *Google Scholar*

In addition, we included some articles that were cited in the selected papers. To narrow the scope, we focused on empirically tested approaches. Lastly, we give our last statement about flow and game AI in Section 10.

3. The theory of flow

In this section, we present a brief introduction to the Theory of Flow. We focus on explaining its main constructs and how they have been evolving over time. Furthermore, we give examples of contexts in which it has been successfully applied and evaluated.

Back in the mid-seventies, flow research started in a endeavor to understand this subjective state, characterized by an intense level of attention, that people experienced while performing an intrinsically motivated activity [7]. This phenomenon was called flow, and it is defined as follows:

> Being “in flow” is the way that some interviewees described the subjective experience of engaging just-manageable challenges by tackling a series of goals, continuously processing feedback about progress, and adjusting action based on this feedback. – Nakamura and Csikszentmihalyi [17].

Also, it has been found that a subject can experience a state of flow in a variety of activities [4,6,16,17], such as: dancing, rock climbing, playing chess or a video game. In addition, it was observed that a state of flow could be described by the following characteristics [7]:

- Full immersion in the task
- Feeling of full control
- Being less conscious of the passage of time
- Sense of identity lessens, but is reinforced afterwards

However, all these characteristics are not necessarily present in a flow state. The only defining quality of flow is that attention is fully invested in the task at hand. Also, these investigations have discovered that flow is a state of optimal experience; people enjoy the most when achieving the subjective state of consciousness known as flow [7]. Arguably, this consequence of achieving a flow is the main cause of the motivation to adapt flow constructs to a video game context.

Further research identified that when a subject performs a low skill and challenging task, apathy is experienced although she is in the flow channel, according to the original model of flow [7] (Fig. 1). Because of this finding, the conditions needed to drive a subject to a flow state changed, and the eight channel model of flow has been proposed [17] (Fig. 2). According to this new model, a subject may be able to achieve a flow state if the perceived challenge and skills are above his/her mean levels [17]. In Fig. 2 it is shown that when challenge and skills are below the subject’s mean, apathy is experienced.

Another aspect that has been identified as key to achieve a flow state is an autotelic personality of the subject. Although the skill to achieve a state of flow is present in almost all people, the frequency and quality of the experience vary from subject to subject [17]. It

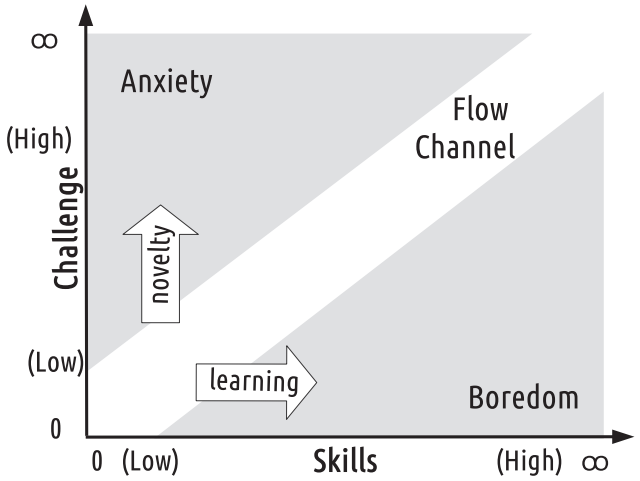

Fig. 1. The original three-dimensional model of flow (reproduced from [7]). In this figure, we can see how important is the challenge/skill balance precursor. If the player does not stay in the flow channel, his/her experience is not optimal. If the challenge she is facing is *below* his/her skills, *boredom* is experienced. Conversely, if the challenge she is facing is *above* her skills, *anxiety* is experienced.