# Game Content Generation of Super Mario Bros. Using Interactive Evolutionary Computation

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**Abstract.** The study introduces a game content generation framework for the *Super Mario Bros.* game. This framework leverages the strengths of interactive evolutionary computation (IEC) and generative adversarial networks (GAN), facilitating the generation of diverse and creative game content. Additionally, players can utilize the designed interactive game console for both interactive game content generation and immersive gameplay.

**Keywords:** Interactive Evolutionary Computation · Super Mario· Game Design

## 1 Introduction

As games expand in size and complexity, developers face the challenge of creating vast amounts of game content, ranging from maps and levels to props and quests. Manual content creation is not only time-consuming and labor-intensive, but also struggles to keep pace with player demands and game evolution. Thankfully, procedural content generation (PCG) offers a solution [2]. PCG utilizes algorithms and randomness to generate game content, making it a pivotal technology in the game development domain. With the advancement of machine learning, PCG technology has seen significant improvement, enhancing development efficiency and quality while simultaneously reducing costs and time commitments.

To this end, the study aims to propose a game content generation framework for the *Super Mario Bros.* game (abbreviated as *Super Mario*). This framework leverages the strengths of IEC and GAN, facilitating the generation of diverse and creative game content. Additionally, players can utilize the designed interactive game console for both interactive game generation and immersive gameplay. Next, we will present technical details and game cases of the proposed framework and console.

## 2 Technical Details

The study introduces a game content generation framework for the *Super Mario*. This framework leverages the strengths of IEC and GAN, facilitating the generation of diverse and creative game content. It combines the ability of IEC to acquire user player

preferences and the powerful generation ability of GAN [1, 4]. The entire framework's implementation is based on the Python programming language, and the training of GAN's model is conducted using the PyTorch deep learning framework.

The interaction design framework proposed in this study is based on the video game level corpus (VGLC) [3], a resource library containing a dataset of video game levels, including *Super Mario*, *Doom*, *Kid Icarus*, *The Legend of Zelda*, and others. This corpus aims to collect, organize, and share level data of various video games for researching, analyzing, and developing related algorithms and methods. The game content level of *Super Mario* is represented by a tile block visualization mapping defined by the VGLC.

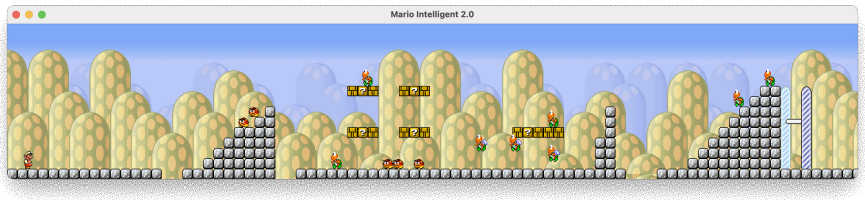
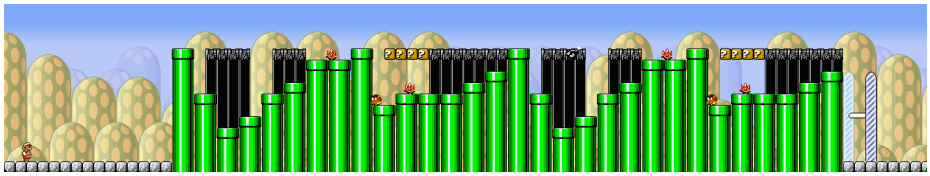



**Fig. 1.** Immersive Gaming Interface. Players can choose their favorite game level for immersive gameplay.

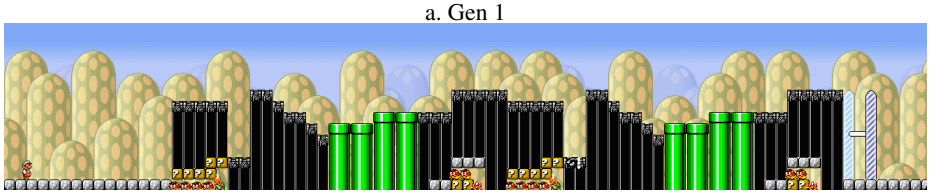
We designed an interactive game console based on JFrame for this study. JFrame is an essential class in Java used to create graphical user interfaces (GUI), part of the Javax.swing package. It offers methods for creating and managing windows, enabling developers to construct desktop applications with interactive capabilities. Various components, including buttons, image boxes, and labels, can be added to build user interfaces using JFrame. Furthermore, JFrame provides numerous methods for setting properties such as window size, position, title, and handling window events. Fig. 1 illustrates a player immersively controlling Mario's gameplay process.

## 3 Game Design Case

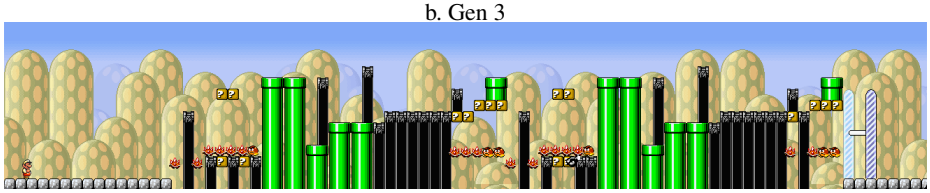
In this section, we will introduce the game content generated through our proposed framework. In Fig. 2, the game content cases of four generations generated by a player using the proposed framework are displayed. Notably, Fig. (a) depicts the initial scene with relatively simple features, while as the evolution progresses, the generated content and scenes become increasingly complex and diverse. A comparison between Figs. (a) and (d) reveals a significant enhancement in the diversity of game content generated by players through the proposed framework, owing to the continuous interactive evolution. This improvement can be attributed to the successful acquisition of player preferences for game scenes by IEC, which then converts them into user-guided latent vectors input into GAN for regenerating new game content. The proposal presents a novel way to contribute to game content design in the industry.



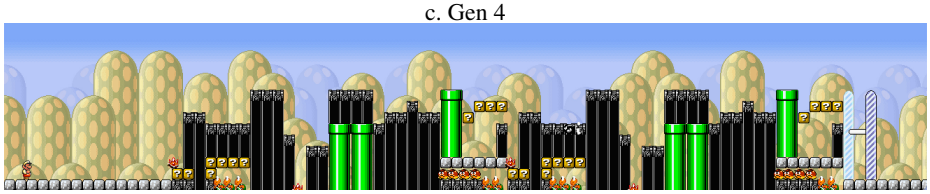
a. Gen 1



b. Gen 3



c. Gen 4



d. Gen 7

**Fig. 2.** Visualize the game level solutions generated by the proposed framework across different generations, aiming to demonstrate the diversity of generated by the proposed framework. 'Gen 1' represents the solution chosen by a player in the first generation.

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