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ALGORITHMS FOR EVALUATING CREATIVE PLAYER ACTIONS IN GAME SIMULATORS

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Анотація

У тезах розглядаються алгоритми оцінювання творчих дій гравця у симуляторах творчої діяльності. Проаналізовано основні підходи до формалізації та вимірювання творчості в ігровому контексті, включаючи евристичні методи, машинне навчання та комбіновані підходи. Запропоновано класифікацію методів оцінювання та визначено критерії якості оцінки творчих дій. Особливу увагу приділено питанням прогресії гравця та динамічної адаптації алгоритмів оцінювання залежно від рівня майстерності.

Ключові слова: творчий симулятор, оцінювання творчості, алгоритми оцінки, прогресія гравця, ігровий штучний інтелект, евристичні методи, машинне навчання.

Abstract

This paper examines algorithms for evaluating creative player actions in creative activity simulators. The main approaches to the formalization and measurement of creativity in a gaming context are analyzed, including heuristic methods, machine learning, and combined approaches. A classification of evaluation methods is proposed, and quality criteria for assessing creative actions are defined. Special attention is paid to player progression and the dynamic adaptation of evaluation algorithms depending on the level of mastery.

Keywords: creative simulator, creativity evaluation, assessment algorithms, player progression, game artificial intelligence, heuristic methods, machine learning.

Introduction

The rapid development of game technologies and artificial intelligence has given rise to a new category of software products – creative activity simulators. Unlike traditional games, these systems aim not only to entertain the player but also to stimulate, measure, and reward creative thinking and non-standard solutions. Examples include music composition simulators, game-based design environments, architectural modeling tools, and artistic drawing games [1].

One of the central challenges in the development of such simulators is the design of reliable algorithms capable of evaluating creative actions objectively and constructively. This task is fundamentally difficult because creativity, by its nature, is a multidimensional and subjective phenomenon. However, recent advances in computational creativity, natural language processing, and deep learning have opened new opportunities for algorithmic assessment [2].

The relevance of this topic is further underscored by the growing interest in gamification of educational and professional processes. When simulators can accurately assess creative output, they become powerful tools for self-improvement and skill development. A properly designed evaluation algorithm enables the system to guide the player toward growth, provide meaningful feedback, and adapt the difficulty of tasks to match the player's evolving level of mastery [3].

The purpose of this research paper is to survey and systematize the main algorithmic approaches to evaluating creative player actions in game simulators, to analyze their strengths and limitations, and to propose criteria for selecting appropriate methods depending on the type of creative activity simulated.

Definition and Challenges of Creativity Evaluation in Games

Creativity in the context of game simulators can be defined as the player's ability to generate actions, artifacts, or solutions that are novel, appropriate within the game context, and surprising relative to a given baseline. Researchers in computational creativity typically decompose this construct into three components: novelty, appropriateness, and usefulness [4]. In game simulators, these components must be operationalized into computable metrics.

The challenges of algorithmic creativity assessment are significant. First, the reference space for novelty

depends on what the system considers ‘already known’ – this requires maintaining a model of prior player actions. Second, appropriateness is domain-specific: a creative action in a music simulator must be evaluated according to harmonic and rhythmic rules, while in a visual design simulator it depends on aesthetic and compositional principles. Third, the system must balance objective metrics with subjective player experience to avoid discouraging exploration [5].

Classification of Evaluation Algorithms

The existing approaches to evaluating creative actions in game simulators can be systematized into three major categories: rule-based (heuristic) methods, machine learning-based methods, and hybrid approaches [6]. Table 1 summarizes these categories with their main characteristics, advantages, and limitations.

Table 1 – Classification of algorithms for creative action evaluation

Category	Description	Advantages	Limitations
Rule-based (Heuristic)	Predefined rules and scoring criteria based on domain knowledge	Fast, interpretable, domain-consistent	Limited flexibility; cannot detect truly novel creativity
Machine Learning (ML)	Trained models (CNN, RNN, Transformers) learn patterns of quality	Captures complex patterns; scalable to large datasets	Requires large labeled datasets; black-box nature
Hybrid (Combined)	Combines rule-based constraints with ML-based generalization	Balances interpretability and learning capacity	Complex to design and tune; higher computational cost
Procedural / Generative	Uses procedural content generation to compare player output against generative model	Adaptive to player style; dynamic benchmark	Generative model quality directly affects evaluation fairness

Heuristic Methods

Heuristic methods represent the most traditional approach to creativity evaluation. They rely on expert knowledge encoded as rules or scoring rubrics. In music-based game simulators, for example, heuristic algorithms may assign points based on harmonic consonance, rhythmic complexity, and melodic contour deviation from the expected pattern [7]. In visual art simulators, rules may evaluate color contrast, compositional balance, and object placement symmetry.

The primary advantage of heuristic methods is their transparency: the player can receive specific, interpretable feedback. However, these methods are constrained by the completeness of the ruleset. Truly innovative creative actions that fall outside the predefined categories may be penalized or go unrecognized [8].

Machine Learning Approaches

Machine learning methods have become increasingly prevalent in creative evaluation tasks. Convolutional neural networks (CNNs) have demonstrated effectiveness in evaluating visual creativity by learning features associated with aesthetic quality from large datasets of human-rated artworks. Recurrent neural networks (RNNs) and Transformer architectures are commonly applied to sequential creative outputs such as music compositions in text-based simulators [9].

Reinforcement learning (RL) offers another promising direction. In this paradigm, an agent trained on a large corpus of creative works can serve as an internal critic, scoring player actions against learned standards of quality. The reward signal from this critic is then used both for evaluation and for shaping the difficulty curve of the simulator [10]. A critical limitation of purely ML-based approaches is their dependency on training data quality, which may lead to culturally narrow evaluations.

Hybrid and Adaptive Approaches

The most promising direction in current research is the development of hybrid evaluation systems that combine the interpretability of heuristic methods with the generalization power of machine learning. A typical architecture involves: (1) a rule-based module that checks domain constraints, (2) an ML module that scores higher-level creative quality, and (3) an aggregation layer that weights and combines both scores into a final evaluation [11].

Adaptive algorithms adjust their evaluation criteria based on the player’s progression level. A novice player may be evaluated against simpler benchmarks to encourage exploration, while an advanced player is measured

against more demanding standards. Dynamic difficulty adjustment (DDA) systems can be extended to incorporate this adaptive evaluation logic [12].

Criteria for Algorithm Quality Assessment

In order to compare and select appropriate evaluation algorithms, it is necessary to define formal criteria. Table 2 presents a set of quality criteria for creative evaluation algorithms in game simulators, along with their definitions and relevance for player progression systems.

Table 2 – Quality criteria for creative evaluation algorithms

Criterion	Definition	Importance for Progression
Validity	The algorithm measures what it intends to measure (actual creativity)	High – invalid metrics mislead player development
Reliability	Consistent results for similar inputs across evaluations	High – inconsistency frustrates players
Interpretability	Degree to which the evaluation result can be explained to the player	Medium-High – essential for formative feedback
Adaptability	Ability to adjust criteria based on player level and context	High – critical for dynamic progression systems
Computational Efficiency	Processing speed relative to game's real-time requirements	Medium – low-latency feedback improves immersion
Cultural Neutrality	Freedom from culturally specific biases in evaluation	Medium – important for global audiences

Player Progression and Evaluation Feedback Loops

The integration of creativity evaluation algorithms into player progression systems creates a feedback loop that fundamentally shapes the simulator's pedagogical value. When an evaluation algorithm accurately detects and rewards creative growth, it reinforces exploratory behavior and encourages players to move beyond habitual patterns. Conversely, a poorly calibrated algorithm may create a ceiling effect where the player's creativity stagnates [13].

A recommended architecture for a progression-integrated evaluation system involves three layers: (1) the action capture layer, which records player actions in a structured format; (2) the evaluation layer, which applies multi-dimensional scoring using hybrid algorithms; and (3) the progression layer, which maps evaluation scores to experience points, level-up thresholds, and unlockable content. This architecture ensures that creativity is not only recognized but also rewarded in a manner meaningful to the player [14].

Conclusions

This research paper has presented a systematic review of algorithms for evaluating creative player actions in game simulators. The analysis demonstrates that no single algorithmic approach is universally optimal: heuristic methods offer interpretability but lack flexibility; machine learning approaches capture complex creative patterns but require substantial training data and lack transparency; hybrid approaches represent the most balanced solution for production-ready creative simulators.

The proposed classification of evaluation methods and the set of quality criteria provide a structured framework for developers and researchers when selecting or designing evaluation algorithms for specific types of creative simulators. Of particular importance is the criterion of adaptability, which enables evaluation algorithms to support dynamic player progression by adjusting their standards to the player's evolving skill level.

Future research should focus on the development of culturally neutral evaluation models, the integration of player-centric explainability mechanisms, and the use of generative AI as a dynamic benchmark for creativity assessment. The ultimate goal is to create evaluation systems that not only measure creative output but actively inspire and nurture creative growth in players.

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