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Authors

Miller, Chris

Jhala, Arnav

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An Observer-oriented Theory of Creativity and Aesthetic Measure

Chris Miller and Arnav Jhala
Department of Computer Science
North Carolina State University
Raleigh, NC 27695
{ cwmille6 | ahjhala }@ncsu.edu

Abstract

As a step toward computational modeling of cognitive processes and interpretation of creativity, we present an extended theory of computational creative systems that aims to better define the evaluation of creative systems and processes. Previous research has focused largely on the *generation* aspect of creative systems. This paper extends this formalism by modeling the *judgment* of creativity through computational models of *observer* systems. As a concrete illustration of its applicability, we show how this theory can support the interpretation of MacGyver problems—problems defined in the cognitive systems research community as classical planning problems designed to elucidate the cognitive process of creative problem solving. Finally, we demonstrate how this theory provides an interpretation to previous empirical work in approximation of an aesthetic measure in artistic domains for individual and group preferences over photographs and gestural performances. Our overall contributions are: (a) an initial formal model of creativity that incorporates a generative process and a given observer (b) application of the theory to interpretation of results from both symbolic (classical planning) and statistical (preference learning) approaches.

Introduction

The motivation for our work on understanding creativity and the creative process begins with Boden's seminal work on understanding creative behavior described in her book, *The Creative Mind* (2004). In this book, Boden sets out to describe human creativity, creative behavior, and how computers can help us understand creativity. Boden's approach is qualitative and provides insight into the development of a formal framework to explain the ideas in a way that is amenable to computational analysis and representation. This paper presents work that provides an initial computationally amenable formalization of creative systems. Furthermore, it incorporates an account of creativity that takes into account an observer/evaluation system. Prior research on creativity primarily looks at creativity from the point of view of creation, not interpretation. The key contribution that we provide in this paper is a detailed formal account of creativity that affords study of design, perception, and evaluation of creative systems. The formalization defines a generator/creator in terms of a machine that creates a range of artifacts given a domain vocabulary and a set of composition rules, and an observer machine that interprets given artifacts given a set of symbols and rules. Creativity can then be quantified in terms of the expressive range of generator systems, comparison of their domain vocabulary and rules, and efficiency of generating artifacts with respect to a given observer.

Wiggins (2006) proposes a detailed framework for describing, analyzing, and comparing creative systems. Inspired by Boden's description of *psychological creativity*, we propose an extension to Wiggins' framework to account for the subjective evaluation of potentially creative systems and artefacts. In this extended framework, we present the perception of creativity as the subjective judgment of an observer with varying amounts of domain knowledge. We then expand Wiggins' initial definition of evaluation in creative systems by putting forth general criteria of subjective evaluation based on previous empirical work regarding aesthetic measure across artistic domains.

In addition to presenting the formalism, we show how this theory can express accounts of creativity across two very different perspectives, one from cognitive systems and one from empirical models of aesthetic evaluation. In particular, we reinterpret MacGyver problems described by Sarathy and Scheutz (2018). The formulation of MacGyver problems represents a step towards designing creative cognitive systems while also introducing a fruitful class of problems for the cognitive systems research community to tackle.

Background: Research Foundation

Boden on creativity

Boden (2004) defines creativity as the ability to "come up with ideas or artefacts that are *new, surprising and valuable*". Researchers generally agree that *novelty* and *value* are two essential criteria for creativity (Oman & Tumer, 2009) and we will do the same in our framework. Boden's analysis of creativity starts by defining two particular cases of creativity: *psychological creativity* and *historical creativity* (also referred to as P-creativity and H-creativity respectively). Psychological creativity describes a creative process through which an idea is created that is new to the person who came up with the idea. Historical creativity is a special case of P-creativity wherein an idea is created that no one else has

ever had before (i.e. completely new in a societal context). P-creativity and H-creativity are *very* context-specific. Our analysis of creativity will focus primarily on the fundamental idea of P-creativity which frames any evaluation of creativity as an evaluation of creativity from an individual's perspective.

Wiggins' creative systems framework

Wiggins' (2006) creative systems framework begins by defining a *universe*, $\mathscr{U}$, a multidimensional space that can represent anything. All possible concepts exist as distinct points in the multidimensional space defined by $\mathscr{U}$. Following the state-space analogy of Boden's initial conceptual space definition, $\mathscr{U}$ is capable of representing all abstract and complete concepts and contains both complete and incomplete artefacts; this includes the empty concept $\top$. Hence, $\mathscr{U}$ contains all possible concepts, including the empty concept $\top$. Additionally, all concepts in $\mathscr{U}$ are distinct (i.e. no two concepts in $\mathscr{U}$ are identical to one another).

To define the conceptual spaces of $\mathscr{U}$, two rule sets, $\mathscr{R}$ and $\mathscr{T}$, are introduced. $\mathscr{R}$ represents the rules that constrain (i.e. sculpt) the conceptual space and $\mathscr{T}$ represents the rules that determine how to traverse the conceptual space. In the context of answer set programming, $\mathscr{R}$ can be likened to constraints which omit potential solutions exhibiting properties that the constraints specify as invalid—thereby constraining the space of potentially valid solutions (Smith & Mateas, 2011). In the context of state-space search, $\mathscr{T}$ can be likened to search strategies (e.g. heuristics) for informed search through states. $\mathscr{R}$ and $\mathscr{T}$ are further defined as belonging to a language $\mathscr{L}$ composed from an alphabet $\mathscr{A}$. The last step required for formally defining a conceptual space is defining an interpretation function. [[.]] is defined as a partial function that maps from $\mathscr{L}$ to real number functions that return a real number in [0,1] which is then mapped to either `true` or `false` depending on its value. With the above definitions of $\mathscr{U}$, $\mathscr{R}$, and the interpretation function [[.]], a conceptual space, $\mathscr{C}$, is defined as:

$$\mathscr{C} = [[\mathscr{R}]](\mathscr{U}) \tag{1}$$

By this definition, a conceptual space, $\mathscr{C}$, is defined by the interpretation, [[.]], of rules defining how to constrain *and* define a conceptual space, $\mathscr{R}$, applied to a larger multidimensional space, $\mathscr{U}$. Additionally, now the distinction between $\mathscr{R}$ and $\mathscr{T}$ is more apparent; $\mathscr{R}$ defines rules that apply to $\mathscr{U}$ to describe a whole domain of acceptable artifacts whereas $\mathscr{T}$ defines traversal rules (e.g. heuristics) for exploring possible artifacts within the domain defined by $\mathscr{R}$.

In order to account for the traversal (i.e. exploration) of conceptual spaces via $\mathscr{T}$, another interpreter $\langle\langle .,.,. \rangle\rangle$ is defined. $\langle\langle .,.,. \rangle\rangle$ takes as input three subsets of $\mathscr{L}$, namely $\mathscr{R}$, $\mathscr{T}$, and $\mathscr{E}$ which will be briefly described soon. $\langle\langle .,.,. \rangle\rangle$ operates on a totally ordered subset of $\mathscr{U}$, c_{in}, and maps it to another totally ordered subset, c_{out}. Namely,

$$c_{out} = \langle\langle \mathscr{R}, \mathscr{T}, \mathscr{E} \rangle\rangle(c_{in}) \tag{2}$$

These formalizations more rigorously define Boden's idea of conceptual spaces for creativity and can already describe Boden's (2004) exploratory and transformational creativity. Transformational creativity can be achieved by either transforming $\mathscr{R}$ or $\mathscr{T}$.

$\mathscr{E}$ is described as a set of rules that allows for the evaluation of concepts in $\mathscr{C}$ and determination of their value. For reasons that will become apparent later, Wiggins' framework consciously chooses to avoid discussing how to evaluate these concepts and leaves it as an important issue to be discussed at a later time.

It should be noted that previous research has explored how to evaluate artefacts and provide preliminary frameworks for evaluating creativity in specific domains but little research has been done to define the evaluation of creativity in terms of an explicit observer of varying knowledge and expertise (Ritchie, 2001).

Theory of creative systems

Defining an observer

We start by defining an observer, $\mathscr{O}$, of a creative process:

> **Definition 1** (*Observer*). An observer, $\mathscr{O}$, is an entity capable of representing concepts in the multidimensional space $\mathscr{U}$.

Given that $\mathscr{U}$ defines the universe of possibilities of a creative process' conceptual space, $\mathscr{O}$ describes an observing entity with the *potential* to re-represent concepts in the universe of possibilities $\mathscr{U}$. By our definition an observer can be a human or even a computational system. In fact, observers can be represented as generative systems that produce artefacts in their respective conceptual spaces. This idea of *potential re-representation* is particularly important because not every observer, $\mathscr{O}$, can be assumed to be capable of representing any *and* all concepts in $\mathscr{U}$. It is for this reason that we define a special type of observer which we shall call the *omniscient oracle* $\mathscr{O}_o$. The omniscient oracle is an observer capable of representing any *and* all concepts in $\mathscr{U}$. By our definition, the omniscient oracle as described here is an observer for which nothing is creative due to its complete representation of $\mathscr{U}$. This distinction between observers and the omniscient oracle leads to the following axiom:

> **Axiom 1** (*Restricted observer representation*). Any observer, $\mathscr{O}$, that is not the omniscient oracle can only represent conceptual spaces, $\mathscr{C}$, that are proper subsets of $\mathscr{U}$. $\mathscr{C} \subsetneq \mathscr{U}$.

The above axiom restates the conclusion that any observer that is not the omniscient observer can only re-represent parts of $\mathscr{U}$ but never the entirety of $\mathscr{U}$. We would also like to explicitly state that *multiple observers can exist simultaneously*. Given the definition stating that an observer, $\mathscr{O}$, can potentially re-represent concepts in the universe $\mathscr{U}$, we now define *how* observers represent these concepts.

Defining an observer's conceptual space

A fundamental property of observers is that all observers possess their own, individual rule sets $\mathscr{R}_o$ and $\mathscr{T}_o$. These rule sets are analogous to $\mathscr{R}$ and $\mathscr{T}$ defined earlier except that they are particular to an observer, $\mathscr{O}$, rather than being generally defined for a creative process. Hence, $\mathscr{R}_o$ represents an observer's specific rules for constraining a conceptual space and $\mathscr{T}_o$ represents their specific rules for traversing a conceptual space. In practice, these rule sets represent the extent to which an observer is able to define domains within $\mathscr{U}$ as well as explore concepts within it. As such, these rule sets effectively represent an observer's knowledge of domains in $\mathscr{U}$.

Using the interpretation function [[.]] from earlier which works on well-formed rule sets described in a language $\mathscr{L}$, we can define the conceptual space of an observer $\mathscr{O}$ as follows:

$$\mathscr{C}_o = [[\mathscr{R}_o]](\mathscr{U}) \tag{3}$$

There are a few things which should be stated:

1. The interpretation function [[.]] is defined such that as long as a constraining rule set, $\mathscr{R}$, is a well-formed rule set, it can be successfully interpreted and this interpretation works for any well-formed rule set in $\mathscr{U}$.

2. Given that the conceptual spaces of any observer, $\mathscr{C}_o$, must exist within $\mathscr{U}$, interpreting $\mathscr{R}_o$ within $\mathscr{U}$ yields $\mathscr{C}_o$.

3. The same universe, $\mathscr{U}$, can be used to describe the conceptual spaces of different observers with different rule sets.

This definition formalizes the idea that observers' conceptual spaces are subsets of the universe of possibilities $\mathscr{U}$.

We would also like to revisit how conceptual space restraining rules may be interpreted by a system. Let r be a rule defined in the rule set $\mathscr{R}$. We refrain from stating that concepts that violate r are immediately excluded from the constrained conceptual space given that numerous rules can be defined in $\mathscr{R}$ and they need not be mutually exclusive. For example, consider the following rules in the context of music composition:

1. Produce musical scores using a tempo of 120 beats per minute (bpm).

2. Produce musical scores using at least two different instruments.

If the rules are not explicitly defined as being mutually exclusive, acceptable concepts can include artefacts that only use a tempo of 120 bpm, only use at least two different instruments, or both. If these are the only two rules applied to $\mathscr{U}$, then $\mathscr{C}$ will include concepts that satisfy at least one of the rules in $\mathscr{R}$ while excluding the rest. Regardless, the issue of rule exclusiveness is a design choice which can be delegated to the rule interpretation function [[.]]. We envision that a key challenge in an implemented system will be being able to recognize and handle rules that conflict and or contradict each other.

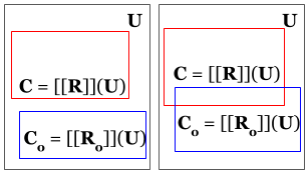


Figure 1: Illustration of how two example conceptual spaces, $\mathscr{C}$ and $\mathscr{C}_o$, exist within $\mathscr{U}$. **Left**: No intersection of concepts belonging to the creator and the observer. **Right**: Intersection of concepts belonging to the creator and the observer.

Defining the observer in relation to the creator

We begin our theory's components on subjective evaluation by first highlighting the relationship between the observer and the general creative process defined by Wiggins' (2006) preliminary creative systems framework. This process is a formalization of how some entity (henceforth called the *creator*) defines its conceptual space and explores and transforms conceptual spaces to exhibit potentially creative behavior in the course of creating new and valuable artefacts in the context of a universe of possibilities $\mathscr{U}$. We use the term "creator" to emphasize the fact that the entity engaging in exploring and redefining conceptual spaces in $\mathscr{U}$ seeks to generate creative artefacts and can be a human creator or another generative system. We can now phrase an observation from earlier as follows:

> **Observation 1** (*Shared universal context*). The creator and observer(s) share the same universal context $\mathscr{U}$.

This illustrates that the conceptual spaces of the creator and the observer(s) all exist within the same universe. Given that our viewpoint of the observer defines an observer as an independent onlooker to the creator's creative process, the creator's conceptual space defining rule sets, $\mathscr{R}$ and $\mathscr{T}$, are independent from those of the observer(s), $\mathscr{R}_o$ and $\mathscr{T}_o$. This leads to the follow observation which is illustrated in Figure 1:

> **Observation 2** (*Independence of creator/observer concepts*). The conceptual space of the creator, $\mathscr{C}$, and the conceptual space of the observer, $\mathscr{C}_o$, are defined independently of each other but are both subsets of $\mathscr{U}$. (Note: If there are multiple observers, each respective $\mathscr{C}_o$ is defined independently of the other observers' conceptual spaces.)

The idea of independence between these conceptual spaces only extends to how they are independently defined by their individual originators. If $\mathscr{R}$ and $\mathscr{R}_o$ contain similar rules, $\mathscr{C}$ and $\mathscr{C}_o$ will overlap which in turn means that the observer is able to conceive of *some* concepts in the conceptual space of the creator (as determined by the amount of intersection) and vice versa. This is evident in the image on the right in Figure 1. With this knowledge we are now able to state how and when the observer might consider the creator (and its corresponding creative process) as being creative.

An initial definition of the subjective evaluation of creativity

Our definition of an observer's subjective evaluation of creativity begins with the following postulate:

> **Postulate 1**: an observer is likely to consider concepts that are not explicitly defined in their conceptual space, $\mathscr{C}_o$, but appear in the conceptual space of a creator, $\mathscr{C}$, as being creative.

These concepts represent artefacts and ideas that lie outside of the observer's *explicitly* known artefact range and represent a class of concepts that are new to the observer. We have based this postulate on the essential criteria of creativity which suggests that creative ideas and artefacts are novel.

We can also represent concepts that are new to the creator by framing the creator as its own observer. Therefore, even if another observer may not consider a creator's concept as creative, if the creator came up with a novel idea within their own perspective, the creator can still think that their newly formed idea is creative. An example of this could be a mathematics student independently deriving and proving the Pythagorean theorem despite never being taught it. From the perspective of that student, the result may very well be creative but to the larger mathematics community, the result itself would not be considered creative. This is directly related to Boden's initial formulation of P-creativity and reinforces the contextual aspect of creativity.

The rule sets of the creator and the observer affect the observer's perceived creativity of the creator and its concepts. When the creator's conceptual space includes concepts that are outside of the observer's conceptual space, these concepts are more likely to be deemed creative by the observer. Namely, these concepts exhibit one of the essential criteria of creativity: *novelty*. This leads to the following claim:

> **Claim 1**: an observer's perceived creativity of a creator's process or artefact results from rules that the creator possesses but the observer has not yet incorporated into their own rule set with respect to some application domain.

In consideration of the claim of perceived creativity mentioned above, one might also conjecture that if that an observer adopts previously unknown rules into their rule set, then the observer may no longer consider concepts relying on those rules to appear creative. This describes an observer who expands their domain knowledge as they encounter new concept rules. In this case, the "learned observer" highlights a fundamental challenge of the perception of creativity: the struggle of continuing to be perceived as creative by observers who learn from their exposure to new ideas.

MacGyver problems in cognitive systems research on creative problem solving

Our formulation of the creative systems framework—in particular its emphasis on rule comparison-based creativity evaluation—shares an interesting connection to MacGyver

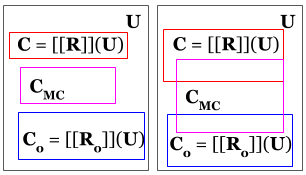


Figure 2: Illustration of the initial states of sample MacGyver problems informally described in the extended creative systems framework. **Left**: No intersection between the space of valid solutions and the observer's known world conceptual space at the initial state. **Right**: Intersection between the space of valid solutions and the observer's known world conceptual space at the initial state.

Problems in cognitive systems research (Sarathy & Scheutz, 2018). MacGyver problems are defined as a class of classical planning problems that are initially unsolvable for an agent given their current knowledge and are designed to showcase how humans solve previously unsolvable problems. As such, MacGyver problems are defined in such a way that if an agent sufficiently expands its domain representation or understanding of its world within the context of a larger universe, the problem can ultimately be solved. These problems are presented as an initial step towards designing creative cognitive systems. Similar to Wiggins' initial framework and subsequently our extended framework, MacGyver problems define a universe consisting of numerous worlds whose *conceptual spaces* within the universe are shaped by the abilities of individual agents of which these agents are either aware or unaware. A key component of the world definition is that worlds only represent portions of the universe that are both *perceivable* and *actionable* by their respective agents. Hence, worlds can be likened to conceptual spaces in $\mathscr{U}$.

We can represent a MacGyver problem in our framework by letting a conceptual space $\mathscr{C}_{Mc}$ describe a class of solutions to a MacGyver problem and by letting the agent trying to solve the MacGyver problem be the creator. By the definition of MacGyver problems, we know that the agent's conceptual space will not initially include any solutions in $\mathscr{C}_{Mc}$. In order to solve the problem, the agent (i.e. creator) is free to explore and transform their conceptual space by defining and redefining their rule sets to hopefully achieve a valid solution defined in $\mathscr{C}_{Mc}$. This is analogous to an agent in a MacGyver problem expanding its domain representation and world understanding. We also define an observer of the agent which represents an onlooker of the agent's attempts at discovering a solution. Once the agent discovers a solution, the onlooking observer can then determine whether or not the agent's solution is creative. For instance, if the agent adopted a rule to solve the problem that the observer had not previously considered or defined within their own world's conceptual space, then the observer may very well consider the agent's overall problem solving process or solution as creative. The subjective aspect of the observer's evaluation of the agent's creativity defined by our framework can also describe a situation wherein the observer does not consider a particular solution to be creative. An example of this would be when the

creator's solution (i.e. expanded world knowledge to reach a solution) already exists within the observer's world. The observer's conceptual space intersects with some part of the class of solution $\mathscr{C}_{Mc}$. This would mean that the agent's solution happened to be a solution of which the observer was already aware. Hence, even if the agent's solution was creative based on their initial knowledge when solving the problem, an observer might not consider it to be creative in their own context. Figure 2 illustrates these two scenarios via their respective images.

General aesthetic measure metric for $\mathscr{E}$

We now return our attention to the evaluation rule set $\mathscr{E}$ from Wiggins' (2006) creative systems framework. In terms of the essential criteria of creativity, $\mathscr{E}$ represents *value*. One of the most difficult aspects of formalizing $\mathscr{E}$ results from the fact that the criteria used for $\mathscr{E}$ can vary depending on the desired attributes of artefacts and the domain. Characterizing $\mathscr{E}$ mirrors one of the key challenges in the design, development, and evaluation of generative systems: defining a metric for the *comparison* of created artefacts. Numerous researchers have also noted that a further challenge in characterizing the *creativity* of a generative system is to utilize the metric of comparison with respect to an *observer* to evaluate the perceived creativity of generated artefacts of the generative system (Karimi et al., 2018; Grace & Maher, 2016).

In order to better define $\mathscr{E}$ in the context of a generalizable, formal framework with an observer, we present empirical work in two artistic domains that illustrates abstract, general properties of aesthetic measure for the evaluation of artefacts.

Generative systems need self- and external-validation in terms of being creative by means of *comparison* of the artefacts it generates. Such a comparison, particularly in terms of creativity, can be seen as a relative measurement of its aesthetic (broadly speaking) appeal to its audience (e.g. an observer). Birkhoff(1933), in his detailed monograph titled *Aesthetic Measure*, defined aesthetic measure as the ratio of *Order* over *Complexity*. This can be understood as the complexity of interpreting the number of features an artifact includes and the amount of regularity observed in the construction of the artifact. Birkhoff demonstrated this by deriving aesthetic values of shapes of varying line compositions and lengths. Birkhoff provides extensive calculations to justify the aesthetic scores that are calculated with his measure for this domain. Some shapes are reproduced in Figure 3.

A contemporary interpretation of aesthetic measure

Computational models of aesthetic measure are challenging to develop due to the lack of functional and interpretable inputs, noise in naturally occurring data sets, and unreliable self-reported data due to different interpretations of embedded content. As a significant component of the evaluation rule set $\mathscr{E}$, aesthetic evaluation of generated artefacts is an important piece in characterizing creativity. For this, we present empirical work in two domains, namely photographic composition and full-body gestural performance (dance), and present experimental results on measuring aesthetic preference for viewers. In these experiments, researchers respectively created corpora with automatically annotated features, and collected human preference ratings through crowdsourcing platforms to get a judgment of *goodness* of artefacts as a proxy for aesthetic evaluation.

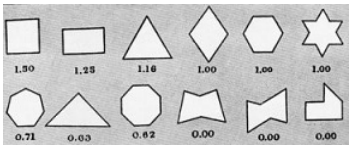


Figure 3: Applied to polygons, Birkhoff's formula for aesthetic value gives a square the highest rating. A five-pointed star (not shown) similar to the one that appears on the flag of the United States has a rating of 0.90. (Ivas Peterson, Science News, May 2004)



Figure 4: Collage of in-game photographs taken from the game Panorama, developed at UC Santa Cruz.

Domain 1: Photographic composition

For understanding visual composition preferences, Swanson, Escoffery, and Jhala (2012) created a corpus of synthetic photographs through a game, *Panorama*, that procedurally generated panoramas with limited palettes of shapes, colors, and objects. Their goal was to create models to compute the overall composition quality of an image with respect to composition features as well as capturing the difference in preferences of individual viewers (see Figure 4). Top-down design of composition metrics, based on photography rules, were combined with bottom-up statistical analysis to correlate aesthetic quality with viewer preferences. Color coded badges in the game functioned as an aesthetic meter, encouraging players to take pictures that rated highly for Rule of Thirds, Balance, and Symmetry. Using their corpus to conduct a preference study, viewer perception of image quality was rated through crowd sourcing on Mechanical Turk.

Within the vocabulary of greyscale panoramic images with a small number of shapes for buildings, trees, meadows, and windmills, the game provided an expressive range of over 250 features such as number of objects, size of objects, location in frame, etc. They conducted a study with pairwise comparison and trained Support Vector Machine based models for aesthetic evaluation. The key insight was that human raters, for whom the algorithm was able to predict with high accu-

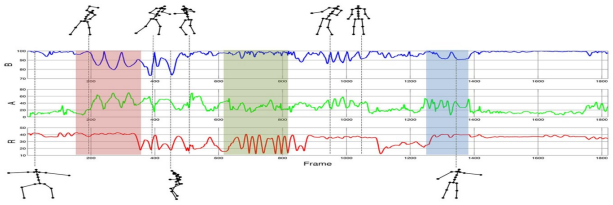


Figure 5: Aesthetic evaluation of dance performance using Balance, Readability, and Asymmetry as higher level features and joint positions and angles as low-level features.

racy ratings for unseen photographs, were consistent in their choice of features for aesthetic evaluation. Users for whom the algorithm was unable to get high prediction accuracy were not consistent with the presence of features in their high rated images. These results highlight some of the challenges for empirical work related to modeling *general* preferences over features of artifacts by different evaluators due to the amount of variation and consistency in raters. There is correlation between prior knowledge and experience with the domain, and consistency of ratings.

Domain 2: Aesthetics of dance

The insights from results of empirical work in photographs are also apparent in similar evaluation of gestural aesthetics. Maraffi, Ishikawa, and Jhala (2013) took the notions of Balance, Symmetry, and Readability in full body gestural performances and defined these high level features in terms of low level joint positions and angles that were captured through a motion-capture camera. Performers in this experiment played the Michael Jackson Experience (MJE) dance game with the Microsoft Kinect. The MJE game provides in-game score to provide feedback on the dances performed by players in terms of degree of match with the original dance for respective songs. This provides three measurements: the in-game score, raw animation data collected from the front facing Kinect depth camera, and high resolution capture from a 14 camera system.

An example performance with high level features is shown in Figure 5. Through an initial survey, performers were divided into two clusters, gamers with experience playing Kinect games but not experienced dancers, and skilled dancers without much experience playing games. The hypothesis was that if the definitions of high level aesthetic features were correct then the algorithm would be able to classify good and bad dancers from observation of their gameplay regardless of their score on the game. Results of this work indicate that the high level features of balance, symmetry, and readability are good indicators of performer skill as judged by independent observers outside the context of gameplay.

Conclusion

In this paper, we extended Wiggins' (2006) creative systems framework by adding a formalism describing an observer inspired by Boden's (2004) description of psychological creativity. To demonstrate applicability of the theory, we reinterpreted MacGyver problems within this framework as an agent's creative search process of expanding its domain descriptive rules well enough to reach any number of problem solutions in a universe of possibilites (Sarathy & Scheutz, 2018). The judgment of whether or not an agent's process of solving a MacGyver problem is creative is then determined by an observer of that agent's creative process. We further related this theory to empirical work on evaluation of aesthetic preferences in creative domains of photography and dance. We have presented this work with the belief that research on formal theories of creativity from the perspective of generation and evaluation systems can greatly benefit how creative processes and artefacts can be fostered by designers of creative cognitive systems and extended to applications such as co-creative and human-computer mixed-initiative systems.

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