Towards a Framework for Multimodal Creativity States Detection from Emotion, Arousal, and Valence

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Abstract. In the multi-disciplinary context of computational creativity and affective human-machine interaction, understanding and detecting creative processes accurately is advantage. This paper introduces a novel computational framework for creatively state detection, employing a multimodal approach that integrates emotions, arousal, and valence. The framework utilizes multimodal inputs to capture the creativity states, with emotion detection forming a foundational element. By fusioning emotions and emotional dimension, arousal, and valence. This paper outlines the theoretical foundations, key components, and integration principles of the proposed framework, paving the way for future advancements in computational creativity and affective computing.

Keywords: Computational Creativity, Affective Human Machine interaction, Multimodal, Emotion detection, Creativity state detection

1 Introduction

As technology becomes increasingly important in our daily lives, its impact on societal aspects also becomes a critical consideration. Technology can take care of the routine and repetitive tasks and provides time for humans to feel more and be creative more [1]. Technology provides the essential elements for human-centric purpose-driven and creative lives which leads to society 0.5 [2, 3]. It can simultaneously facilitate and hinder creativity, as creativity itself possesses both beneficial and destructive aspects.

Computational creativity[4] a growing technological aspect ,involves harnessing computational algorithms and methodologies to generate valuable ideas, solutions, or expressions. For instance, generative models empower machines to produce innovative outputs by amalgamating new permutations or adaptations of existing data [5]. Notably, natural language processing techniques further augment machine creativity by facilitating the generation of coherent and contextually relevant textual content [6]. Despite remarkable strides in simulating creativity, the detection of creative states in humans remains a nuanced pursuit.

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Traditionally, methods such as eye tracking [7], physiological signals [8], and textual or large language analyses [9] have been employed across various contexts to detect creativity.

Creativity, essential for human advancement, fuels innovation across diverse fields, from ancient discoveries to contemporary societal progressions [10]. Emotion serves as a crucial factor, both inspiring and impeding creativity, shaping motivation, idea generation, and perseverance in overcoming obstacles [11, 12]. Understanding creative states empowers individuals to navigate life's challenges, nurturing adaptability and resilience while fostering collaboration and problem-solving [13]. In light of this, our research focuses on assessing creative states through emotions, with the aim of enhancing human-machine interactions and fostering innovative solutions to societal challenges.

How can a multimodal framework be formulated to assess creativity states, considering the factors of emotions, arousal, and valence as the inputs?

Various applications of creativity-aware systems include personalized educational tools, entertainment content, therapeutic interventions, marketing strategies, human-robot collaboration, and assistive technologies, all tailored to individuals' emotional and creative states for enhanced experiences and outcomes [14, 15]. The remainder of this paper is organized to go through the fundamental concepts and then introduce a framework in an attempt provide an answer for the asked question.

2 Background: Creativity and Emotion

Creativity is a multifaceted cognitive process characterized by the generation of novel and valuable ideas, solutions, or expressions that diverge from conventional thinking. It involves the ability to connect seemingly unrelated concepts, think outside established norms, and produce outcomes that exhibit originality, relevance, and often, a degree of surprise [16]. It spans various domains, including the arts, sciences, and everyday problem-solving, reflecting an individual's capacity to navigate ambiguity, embrace curiosity, and engage in the synthesis of disparate elements [17]. The conventional understanding of creativity, as outlined by Runco and Jaeger [18], comprises two elements: **originality** and **effectiveness**, which is also known as appropriateness, usefulness, or meaningfulness. These benchmarks are applicable to the evaluation of creative thinking. Creative thinking is commonly assessed through the lens of generating ideas, particularly emphasizing divergent thinking. **Creative state** is a mental or cognitive condition characterized by enhanced creativity and the ability to generate novel and valuable ideas, solutions, or expressions. Individuals may experience different cognitive and psychological states when engaging in creative tasks. Several drives can contribute to the emergence of a creative state [19]. **Creative Drives** refer to the underlying motivations, forces, or impulses that propel individuals toward creative expression and problem-solving. These drives are the internal or external factors that stimulate and energize the creative process [20].

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Internal drives play a crucial role in fostering creativity, as they emanate from personal passions, curiosities, and the intrinsic motivation to explore, innovate, or express oneself creatively, also they are easier and more accessible to control or be acquire the skills to navigate them [21]. Internal creative drives can encompass a range of psychological factors, such as the emotions, arousal, valence, or the need for self-expression.

Emotions are complex psychological and physiological states that are triggered by various stimuli or situations. They involve a range of subjective experiences, such as feelings, moods, and affective states, that can influence a person's thoughts, behavior, and physiological responses [22]. Research on emotion suggests a concept of emotional abilities, which involves the capacity to think and reason about emotions, engage in problem-solving related to emotions, and utilize emotions for cognitive processes [23, 24]. This perspective is rooted in the idea that emotions convey valuable information that can guide thinking and problem-solving, while also recognizing the intrinsic aspect of emotional experiences that involves emotion regulation [25]. Dimensional theories propose that every emotional experience can be characterized along a minimum of two dimensions, arousal and valence [26, 27]. **Arousal** considered as an emotional dimension. it signifies the degree of physiological and psychological activation within an individual and is linked to the intensity of emotional encounters. It encompasses heightened states of responsiveness across various dimensions, encompassing both bodily reactions and mental engagement [28]. **Valence** denotes the inherent pleasantness or unpleasantness associated with an emotional encounter. It serves as a measure of the subjective appeal or aversion individuals attribute to a specific emotional experience. Valence encapsulates the positive or negative evaluative aspect of emotions, offering insights into the affective quality and the overall emotional tone of a given experience [28].

Circumplex model of Emotion, together, arousal and valence create a two-dimensional space commonly known as the "affective space" or "emotion space." Different emotions can be plotted within this space based on their levels of arousal and valence in the Circumplex model. The model of emotion was developed by James Russell[29]. It organizes emotions into four quadrants within a circular arrangement based on their valence (positive or negative) and arousal (intensity or activation level). Below is an overview of each quadrant along with dominant emotions (see Fig. 1).

Circumplex model and Creativity mapping, creativity is enhanced in the presence of positive emotions such as happiness, cheerfulness, and even anger, as well as during states of boredom[11, 30]. In a series of studies, Isen and her colleagues [31] investigated the impact of emotion on creativity. They revealed that inducing a positive emotions consistently enhanced creative thinking. The hypothesis behind this observation stems from the idea that positive information in memory tends to be more intricately interconnected than negative information for the majority of individuals. Consequently, positive emotional states are posited to facilitate spreading activation, leading to a broader and more diverse

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range of cognitive materials being cued, thereby forming a complex cognitive context [32].

The presence of both positive and negative activated emotional states was linked to increased concurrent creative involvement and in this regard most research resulted that positive emotions and positive activation are in more favoured of creative states [11, 20]. On the other hand, positive and negative deactivating emotional states were connected to decreased levels of creative engagement. In recent research, researchers introduce a holistic model that maps creativity characteristic onto a circular model, illustrating how each quadrant of the model, shaped by the presented emotions, arousal, and valence, can impact creativity as a creativity drives [33].

The model illustrated in Figure 1 represents a mapping to all four quadrants of the Circumplex model to creativity state. The primary aim is to establish a metric that facilitates the assessment of creativity states for machines. *High Arousal, Positive Valence (Excited-Happy Quadrant)* is often conducive to creative thinking and production. The high arousal fuels enthusiasm and energy, while the positive valence supports a mindset open to exploration and generating innovative ideas. It's a state where individuals feel motivated and inspired to bring their creative visions to life. *High Arousal, Negative Valence (Anxious-Angry Quadrant)*, while high arousal in this quadrant signal intensity and focus, the negative valence introduces challenges. Anxiety and frustration hinder the free flow of creative thinking, but controlled stress still drive attention to detail and meticulous creative refinement. *Low Arousal, Negative Valence (Depressed-Sad Quadrant)* presents challenges for creativity. It is associated with feelings of sadness, potentially hindering the motivation and energy required for creative thinking and production. However, periods of introspection and reflection can still be valuable for ideation. *Low Arousal, Positive Valence (Calm-Content Quadrant)* can be beneficial for certain aspects of creativity. A state of calmness and contentment foster a focused and tranquil environment for creative thinking. However, excessive relaxation leads to complacency, so it's essential to strike a balance between tranquility and the necessary arousal for creative energy.

Emotion recognition is the process of identifying and interpreting the emotional state of an individual based on various cues and signals, such as facial expressions, speech, physiological responses, body language, and text. It involves understanding and categorizing the specific emotional experiences that a person is undergoing at a given moment [34].**Unimodal Emotion Recognition**, early efforts in human emotion recognition primarily focused on single modes of expression. Unimodal involves identifying emotions using data from a single source, such as facial expressions or speech signals. It focuses on analyzing one type of modality to infer emotional states [35]. **Multimodal Emotion Recognition**, human tends to show its emotion through several ways. Combining information from various sources or modalities is highly advantageous for improving the accuracy of recognizing emotions[36]. So, essentially, recognizing emotions is best approached as a challenge of understanding emotions through multiple sources or multimodal emotion recognition [37]. Unlike recognizing emotions from just

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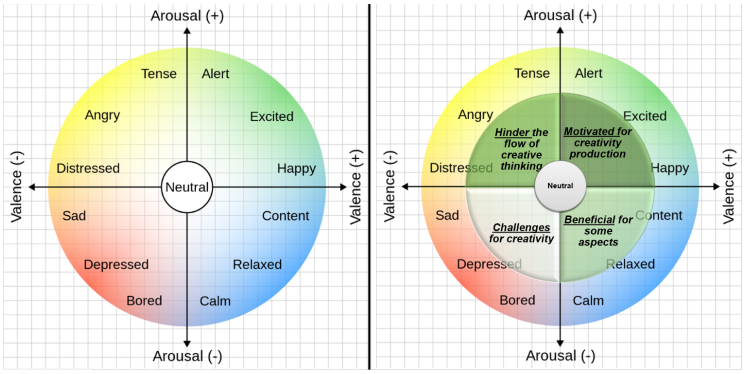

Fig. 1: *Left:* The Circumplex model of emotion. *Right:* Mapping of the creativity states to Circumplex model of emotion.

one source, multimodal emotion recognition looks at many sources of information all at once. However, it can be tricky because even among these methods, some are better at predicting emotions than others [38].

3 Multimodal Creativity State Detection Framework

Equipped with the necessary conceptual foundations and a metric for quantifying creativity states in machines, this section addresses the **MQR** question by formulating a Framework for Multimodal Creativity State Detection. The framework includes Theoretical and Technical components which has been fomulated and shown in Figure 2. The presented framework provides a conceptual overview of multimodal creativity state detection.

Theoretical Approaches is integration of explained psychological and neuroscience theories concerning creativity and its dynamic interaction with emotion, specifically addressing emotional dimensions such as arousal and valence, offers a foundation for establishing a measurable metric for creative state detection. **Technical Approaches** includes, ***Input Modality*** involves determining the modalities of input data for the framework. Modalities may include video, audio, text, and physiological signals. Understanding the nature of the input is crucial for subsequent stages of the framework. ***Feature extraction*** is capturing key characteristics or patterns from the raw data that are indicative of emotional and cognitive states. *Fusion and classification* In this step, features extracted from different modalities are integrated or combined. This fusion process aims to create a representation of the input data. ***Emotion, Arousal, and Valence classification*** involves the detection of emotion, arousal, and valence from the input modalities. ***Creativity State classification***, using the detected emotional components, the framework proceeds to classify the current state of creativity to the measurable metrics. Creativity state classification involves categorizing the individual's creative mindset or expression based on the identified

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emotional and emotional dimention. ***Creativity State Detection*** is the result of creativity state classification by the help of Circumplex model. This output provides result into the individual's current creative state, by the integration of emotion and emotional dimensions.

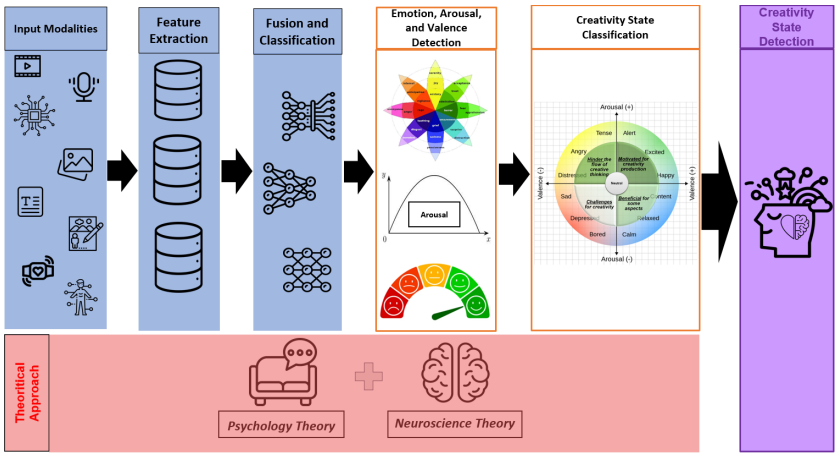

Fig. 2: Multimodal Creativity State Detection Framework

4 Conclusion and Outlooks

This paper introduces a novel metric for assessing creative state using Emotion, Valence, and Arousal, along with a novel multimodal creativity recognition framework within a concrete background review. Creativity is increasingly pivotal in human-machine and human-human interactions. This framework introduces a pathway for fostering higher cognitive collaboration between them. Considering the complexity and evolving nature of the field both theoretical and technological, there are several avenues for future work in the development and enhancements. *Select the appropriate modalities*, identifying suitable modalities and determining effective fusion methods stand out as prominent challenges. Taking into account both theoretical foundations—acknowledging that humans express emotions unevenly across various modalities [39]—and technological preparedness. *Experiments and Validation in real world setting*, and *Consider other creative drives as input modality*, Various creative drivers impact the creative state, and attention stands out as a particularly influential drives[40].

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