Emotional and Multi-agent Systems in Computer-aided Writing and Poetry

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Abstract. MASTER (Multi-Agent System for Text Emotion Representation) is an artificial society in which each member has a digital emotional state. Member agents attempt to influence each other's emotions by reciting "poems" to each other which express their own emotional state. As agents do this, larger texts are developed in the society through social learning. The resulting texts are not meaningful in the normal sense of everyday language - the sound and word repetition generates meaning. Like normal English, there is actually a hierarchical structure to the repetition (i.e. repetitions within repetitions), and the words are often evocative and sometimes contrasting.

1 INTRODUCTION

Some computer poetry research focuses on demonstrating the ability of a technique at simulating poetry, whilst others focus on assisting in the creative acts. This can be viewed as similar to the distinction in computer music between algorithmic composition and computer-aided composition [1]. Computer-aided composition is used as a form of digital collaborator between human and computer which can move the human composer into new areas of creativity, perhaps breaking them out of old habits. In this paper a computer-aided poetry system is introduced, MASTER (Multi-Agent System for Text Emotion Representation) [2]. MASTER is designed to investigate if a Multi-agent System which has no explicit knowledge of how language is constructed, can still help to generate emergent poetry. There has been work on MAS analysing poetry [3] and on MAS being used for story generation and character evolution in prose [4, 5]. As far as we are aware MASTER is the first generative poetry system utilizing multi-agent systems and artificial emotion.

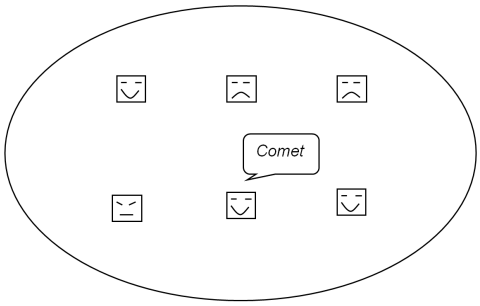

Figure 1: A Heuristic Representation of MASTER

Multi-agent systems (MAS) [6] are composed of multiple interacting intelligent agents. An agent is an autonomous entity which observes and acts upon an environment (i.e. it is an agent) and directs its activity towards achieving goals. Examples of problems which are appropriate to multi-agent systems research include online trading, disaster response, and modelling social structures. A key property of MAS is their ability to generate unexpected or novel responses to problems, sometimes called "emergence" [7]. They have been used successfully in computer-aided composition, because of their emergent properties.

2 COMPUTER POETRY

Common techniques in algorithmic and computer-aided poetry include words being chosen from a hand-crafted dictionary and inserted into a framework [8] (e.g. haiku or sonnet form). It is also possible to make a statistical language model based on existing poems or other texts – this incorporates information about which words / phrases follow which, and their frequency of occurrence [9]. A further approach is to create a set of rules for generating (or re-generating text) based on a manual or automatic analysis of other poetic text [10].

An example output of [9] (Kurzweil's "Cybernetic Poet") is shown below. It is called "Wondered" and is written after the system was trained on the poems of Dave Gitomer:

today i wondered
if i mused
today i saw you
i learned
in awe and you
if i wondered
if i mused
today i had one wish
if i saw you
if i saw you
if i had one wish

Another poet, human this time, who has written in this rhythmic style is the German surrealist Kurtz Schwitters:

What a b what a b what a beauty
What a b what a b what a a
What a beauty beauty be
What a beauty beauty be
What a beauty beauty beauty be be be
What a be what a b what a beauty

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What a b what a b what a a
What a be be be be be
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What a beauty.

Here is an excerpt from another of Schwitters' texts:

> *My corpse is too large, in the night - crumbles, crumbles, crumbles - too large is my corpse. Waters whip unsoftened valley - crumbles, crumbles, crumbles - too large is my corpse, giants arch dome into crumbs - crumbles, crumbles, crumbles, my corpse is too large, Cagliostro's shroud - crumbles crumbles crumbles - my corpse is too large, for the orphanage alms-for-the-poor - crumbles crumbles crumbles - too large is my corpse…*

This form of poetic text is not meaningful in the normal sense, but the sound and word repetition generate meaning. Like normal English, there is actually a hierarchical structure to the repetition (i.e. repetitions within repetitions), and the words are often evocative and sometimes contrasting. The structure of MASTER leads to poetic text of this type, as will now be seen. This approach to generative poetry is consistent with issues founds in AI poetry research, where there can be a trade-off between semantic clarity and rhythmic interest [11]

3 'quiet': A POEM BY MASTER

quiet book comet and fornicate quiet
tourist ignite live quiet quiet book comet and wine ejaculate
and boring welfare fire with fornicate
quiet book comet and rape boring fatigued sadness it quiet
tourist ignite live quiet quiet book comet and wine ejaculate and hysterical rage collaborations fornicate quiet tourist
ignite live quiet
quiet book comet and wine ejaculate and boring
welfare fire with hysterical explosion sensations
explosion explosion provoked explosion
explosion prizes quiet quiet

quiet book comet and wine ejaculate and quiet quiet book comet and fornicate
quiet tourist ignite live quiet
quiet book comet and wine ejaculate and boring welfare
fire with fornicate quiet book comet
and rape boring fatigued sadness
it quiet tourist
ignite live quiet
quiet book comet and wine ejaculate
and hysterical rage collaborations fornicate
quiet tourist ignite live quiet quiet book comet and wine ejaculate and boring
welfare fire with hysterical explosion sensations explosion explosion provoked
explosion explosion prizes want explosion and huge explosion and

This poem was written as a "collaboration" between the first author of this paper and MASTER. The author provided the title and line breaks. MASTER produced the text. This particular implementation of MASTER involved 8 agents who had a slight "depressive" tendency, and 3 of whom were initially "happy", 3 initially "relaxed" and 1 "angry" and 1 "sad". The poem comes from agent 8, after 16 interaction cycles. These terms, and the MASTER system, will now be explained in more detail.

4 MASTER

Before introducing the emotional intelligence of MASTER, affective representation will be briefly discussed. The dimensional approach to specifying emotion utilizes an n-dimensional space made up of emotion "factors". Any emotion can be plotted as some combination of these factors. For example, in many emotional music systems [12] two dimensions are used: Valence and Arousal. In that model, emotions are plotted on a graph (see Figure 2) with the first dimension being how positive or negative the emotion is (Valence), and the second dimension being how intense the physical arousal of the emotion is (Arousal). For example "Happy" is high valence high arousal affective state, and "Stressed" is low valence high arousal state.

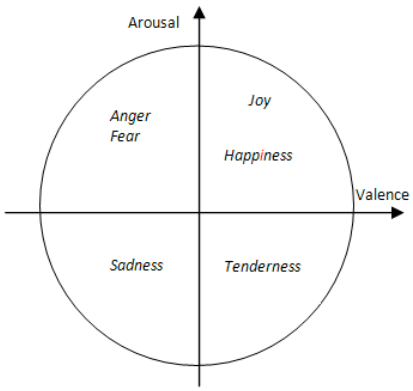

Figure 2: The Valence/Arousal Model of Emotion

Part of the core "emotional intelligence" in the agents in MASTER comes from a 1000 word database called ANEW [13] (Affective Norms for English Words) which each agent has internalized. This pre-prepared database contains a list of words which have had their valence and arousal measured by extensive human experiments. Each human subject was presented with single words and asked to represent their emotional response in a simple computer-based graphical system. The compiled and averaged results have been made available as a database online for academic work, and it is these that are used here. For example in the database "ace" has an average valence of 6.88 and "accuse" has an average valence of 2.54 – i.e. rated significantly less emotionally positive. Similarly "alert" has an average arousal of 6.85 whereas "affection" has a much lower average arousal of 0.86. In the current version of MASTER all agents have the same 1000 words database (although there is nothing to prevent a user from allowing agents to have different emotional word databases.)

Poems are written in MASTER by allowing the agents interact in a specific way. This interaction cycle is shown in Figure 3. In the next two sections, the modules in the diagram will be examined.

5 AGENT A RECITES ITS TEXT

An agent starts with an initial emotional state. This can be neutral (e.g. valence and arousal set to 0), or some bias (e.g. "depressed" with valence = -1, "excited" with arousal = 1, etc). An agent will also have an Initial Text. This can be a single word

chosen by the user, or selected from a database. Agents then take it in turn to recite their text. They will recite to every other agent. This is called a single Cycle. Then it is a second agent's turn to recite for a Cycle, and so forth. So if there are 4 agents it takes 4 interaction cycles for them all to have recited their text to each other.

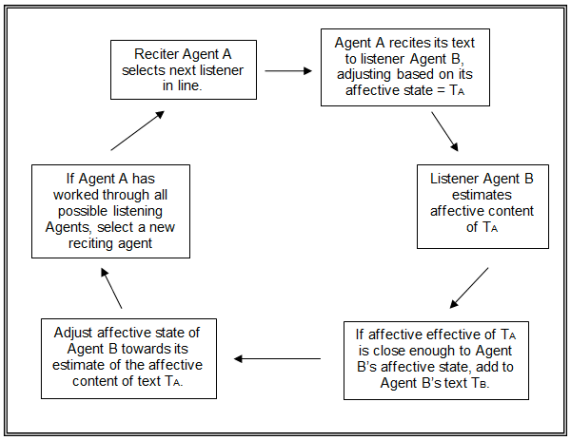

Figure 3. MASTER interaction cycle

An agent's recitation is adjusted by its emotional state. Firstly the reciting agent estimates the valence and arousal of its own stored internal text/poem. To measure valence the agent locates the valence values for all words in its poem which are included in its Emotional Text Database. It calculates the average of these. Not all words in the agent's text will be in the Emotion Database, so it ignores these in the averaging. For example, suppose an agent has the text "Happy smelly death". "Smelly" is not in the ANEW database so will be ignore. But "happy" has valence 0.82 and "death" has valence -0.64. The valence of the phrase is thus calculated as 0.09 (the mean of happy and death).

Arousal is calculated slightly differently. As well as calculating the average arousal from the database, average word length is used. There have been studies that examine the parallels between music and speech [14], in particular ones that support that we understand emotions expressed through music because the music mimics the way emotions are expressed in speech [15, 16]. Because music that has a higher tempo generally expresses a higher arousal [17], MASTER utilizes the concept that phrases with longer words represent a high speech tempo, and thus a higher arousal. Texts with longer (many-syllable) words will tend to read more rapidly, whereas texts with shorter words will tend to have more intra-word gaps and be read more slowly. So in MASTER the longer the average word length, the lower the calculated arousal. The formula is shown in Equation 1. The precise weightings in the formula are designed to combine with the types of values found in the ANEW database, and also to lead to total arousal values of the order -1 to 1 where possible (as commonly used in many valence / arousal models).

$$arousalEstText = 2*average(wordLength)/3 - 1 \quad (1)$$

For example: "Happy Smelly Death" will have a higher arousal (0.87) than "Happy as Death" (0.57), because its average word length is greater.

When estimating the arousal of its internal text, an agent also uses its ANEW database. Then it combines the value in the ANEW database (if the word is in the database) with the value calculated in equation (1), as shown in equation (2), weighting the database arousal contribution twice as much as the word length calculation.

$$arousalEst = (2/3)*arousalDatabase + (1/3)*arousalEstText \quad (2)$$

Part of the logic behind this weighting is that the ANEW database is a highly tested approach to word emotion, whereas equation (1) is very much heuristic and has not been tested on human subjects.

Note that for a human listener the actual affective impact of a word in a sentence is dependent on the words around it – i.e. its context. As a result many systems developed to analyze text emotionally incorporate this context, for example [18]. MASTER's usage of a model where valence and arousal are largely based on individual words' valence and arousal is thus an approximation, but one judged sufficient for this first implementation, and particularly for the type of poetry being examined.

At the end of the above estimation process agent A will then have an estimate of the affective content of its internal stored text. Once an agent has estimated the emotional content of its stored text, it compares this to its own emotional state (its own valence and arousal). If its valence is different to its internal text, the agent adds an emotional word to the end of its text when reciting it to another agent. This is to raise or lower the valence of the text to bring it in line with how it's feeling. It does this by searching through the database for a word whose valence will pull the phrase's estimated valence up or down towards the agent's own current valence, whilst keeping arousal roughly the same.

Similarly if the agent's current arousal is different to its estimation of the arousal of its internal text, then while reciting the agent adds to its text. Firstly, as with valence, it searches the emotion database for a word which will help to adjust its text arousal (but not its valence), and it adds the word to the end of its text. Secondly, it attempts to change the average word length of its phrase while reciting it. This is done using another database the agent has. This is a database of "neutral" words – the Neutral Database. In the current version of MASTER each agent has the same neutral database, provided by the user.

The neutral database can be generated by compiling text from source material from online (e.g. poems, articles etc.) This text is then searched and words are in the emotion database are removed. The remaining list of words is used as the neutral database. This process allows for the user to adjust the neutral database to change the nature of the final generated poems. For example, a neutral database of one of the keynote poets at the Poetry and Source Conference 2012, Plymouth, UK was used in the creation of "quiet".

So the agent searches for a neutral word of an appropriate length to change its text arousal in the right way. For example if it wants to increase the text arousal, it searches for a longer

neutral word. If it wants to decrease text arousal it searches for a shorter neutral word. This is based on equation (1).

5.1 An Example Recital

Suppose agent A has the text "Happy smelly death" and currently has a low valence of -0.5 and high arousal of 0.5 (e.g. "angry"). The ANEW database will estimates the valence of this text as 0.09. So because the agent is "feeling" pretty negative, it wants to adjust the valence of the text to be more negative. It could adjust the sentence valence downwards (from 0.09 towards -0.5) by adding the word "bad" (valence -0.43 from the ANEW database) to its recited text. (Note – these changes are only applied to what the agent recites, not to the text that is stored.)

Now it estimates the arousal of its phrase as 1.06, using the ANEW database and equation (2). It could adjust recital arousal downwards (from 1.06 towards 0.5) by adding the word "calm" (arousal 0.42 in the database) to its recited text. To try and reduce arousal further agent A adds neutral words It adds "of" which has an estimated arousal of 0.33 using equation (1).

So the final text becomes: "Happy smelly death bad calm of". The first three words are Agent A's internal text. The next is to reduce valence, and the last two are to reduce arousal. Using ANEW and equation (2), the calculated valence and arousal of this recital are: valence of 0.06 and arousal of 0.67. So according to that, the agent has decreased valence too little, and increased arousal too little as a result of trying to match its own valence and arousal values (-0.5 and 0.5).

6 AGENT B ESTIMATES AFFECT AND ADDS

When Agent B hears agent A's recitation it estimates the affective content in the same way that that Agent A estimated it in Section 5 above. In other words it estimates the valence from the database, and the arousal using the database and equation (2). Then Agent B will compare that value to its own arousal and valence. If they are close enough in value then Agent B adds Agent A's text to the end of its own internal text – thus updating its internal text. So for example if Agent A recites something "happy" and Agent B feels "happy", then Agent B would add the text to its own. But it Agent B was feeling "sad" it would not. It is through this addition process amongst multiple agents that poems are built up.

Whether or not Agent B adds Agent A's recital to its own text Agent B is effected "emotionally" by hearing the recital. B's own valence and arousal are moved towards the estimated valence and arousal of the recited text from A, using equations (3) and (4). This can be compared to a happy person hearing a sad poem from another person, and it depressing them slightly.

$$valence'_B = (1 - \gamma_v)valence_B + \gamma_v valenceEst_A \quad (3)$$

$$arousal'_B = (1 - \gamma_a)arousal_B + \gamma_a arousalEst_A \quad (4)$$

Thus the interaction of the Agents could be summarized as follows. Agents recite texts to each other, adjusting the recital (adding words to it) based on their emotional state. The agents influence each other's emotional state by the text they recite. When an agent hears a text which has an emotion content close to the way it is "feeling", it adds that text to the end of its own. Thus MASTER is a society of emotional agents who generate in parallel a collection of ever growing poems based on trying to influence each other's emotional states (and communicate their own.)

It could be asked: why don't agents simply adapt their emotional state directly based on other agents' emotional state, rather than via recited words? One reason is that this indirect emotional adaption creates a more interesting dynamical system to generate unpredictable behaviour for creative reasons. A second – less significant - reason for the indirect design is that in fact humans cannot adapt to each other's emotions. We can only estimate other's emotions based on external factors we experience – such as a person's physical behaviour, or tone of voice. We cannot read minds. Thus the situation with MASTER mirrors the human social situation.

There is however a key way in which MASTER differs from emotional influence in humans. When a human aims to influence the emotions of another, they take into account the state of the other human's emotions. So if a happy person wishes to make an angry person happy, they may say different things compared to if they wish to make a depressed person happy. This is the approach that is utilized in much emotional modelling for developing agents in affective computing applications [19, 20]. However for the purposes of a simplified initial implementation, this element is currently not incorporated into MASTER. An agent in MASTER only adjusts its recital based on its own affective state, not the affective state of the agent it is reciting to.

7 ANALYZED EXAMPLE

Consider a MASTER example made up of 3 Agents, with initial valence / arousal states of -0.5/0.5, 0.5/0.5 and 0.5/-0.5. Anthropomorphically these could be thought of as angry, happy and relaxed. The Affective Similarity Threshold is how close an agents affective state must be to the recited text it hears before adding it to its own. This is calculated as the Euclidean distance in the valence / arousal space, and is set to 0.55 for this example. Agents are initialized each with a single word - the word in ANEW whose emotional state is closest to their own emotional state. For example for Agent 2 it is a Happy word (since its initial valence is 0.5, arousal 0.5). So its initial word is "Conquer". A value of 0.1 for the gamma sensitivities in (3) and (4) used. The 3 agents are then left to interact for 20 cycles, with the results shown below:

Cycle 1:

Agent 1's ("angry" agent) initial Text: *"hostage"*
Agent 2's ("happy" agent) initial Text: *"conquer"*
Agent 3's ("relaxed" agent) initial Text: "relaxed"

Cycle 10:

Agent 1 (slightly more happy): *"hostage conquer relaxed bird marry a erotic explosion anticonsumerist relaxed bloom extreme one"*
Agent 2 (slightly more angry): *"conquer relaxed bird marry a relaxed soothe extreme at"*
Agent 3 (slightly more happy): *"relaxed"*

Cycle 15:

Agent 1 (more happy again): *"hostage conquer relaxed bird marry a erotic explosion anticonsumerist relaxed bloom extreme one conquer relaxed bird marry a relaxed soothe extreme at hostage conquer relaxed bird marry a erotic*

explosion anticonsumerist relaxed bloom extreme one extreme shock this infatuation explosion slide"

Agent 2(more angry again): *"conquer relaxed bird marry a relaxed soothe extreme at hostage conquer relaxed bird marry a erotic explosion anticonsumerist relaxed bloom extreme one extreme shock this"*

Agent 3(more happy again): *"relaxed conquer relaxed bird marry a relaxed soothe extreme at hostage conquer relaxed bird marry a erotic explosion anticonsumerist relaxed bloom extreme one extreme shock this infatuation explosion slide"*

The system can be examined more deeply by looking in detail at the emotional internals of a single agent, Agent 1. These changes are shown in Figure 4. Agent 1 starts "Angry", then gradually arousal and valence increases because of influence of the recitals from the happy and relaxed agents. So the agent gets "happier". The agent's internal text estimate approximately tracks this change in emotion, perhaps because of the affective threshold. Agent 2 and 3's emotion evolution is shown in Figure 5.

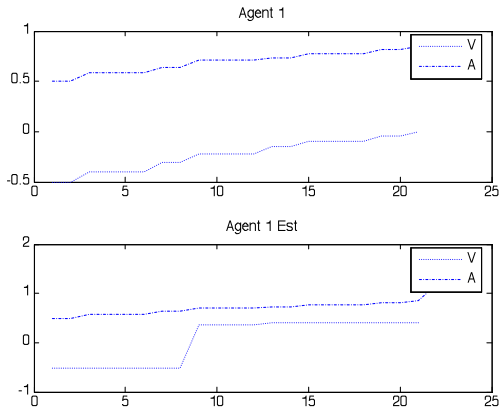

Figure 4: Emotional evolution of Agent 1: Internal state (Top graph); Internal Text Affective Estimate (Bottom Graph)

Simply changing the initial words will change the evolution. For example – requiring that the arousal and valence of the first three initialising words be more emotionally positive and or higher arousal (in this case increased them by 0.4) makes the words selecting from ANEW come up as: "shock", "orgasm" and "snuggle". Then Agent 1's text at 15 cycles becomes:

"shock orgasm shock chaos rage it anxious extreme and orgasm shock chaos rage it snuggle pillow power a shock orgasm shock chaos rage it anxious extreme and hysterical rage the hysterical extreme this snuggle free explosion on orgasm shock chaos rage it snuggle pillow power a shock orgasm shock chaos rage it anxious extreme and hysterical rage the snuggle home extreme at shock orgasm shock chaos rage it anxious extreme and orgasm shock chaos rage it snuggle pillow power a shock orgasm shock chaos rage it anxious extreme and hysterical rage the hysterical extreme this snuggle free explosion on explosion shark this explosion extreme this"

8 QUIET

The poem "quiet" used as the introductory example in Section 3 came from an 8 agent system. The makeup of the initial population was 3 happy and 3 relaxed agents, 1 angry and 1 sad agent. The initial word selected was much lower in valence than arousal than the agent was "feeling" – it was required to be 0.4 below each agent's arousal and valence. The Affective Similarity Threshold was set to 0.43. The poem is the internal text of Agent 8 after 16 cycles. Agent 8's emotional evolution as it wrote the text for quiet can be seen in Figure 6.

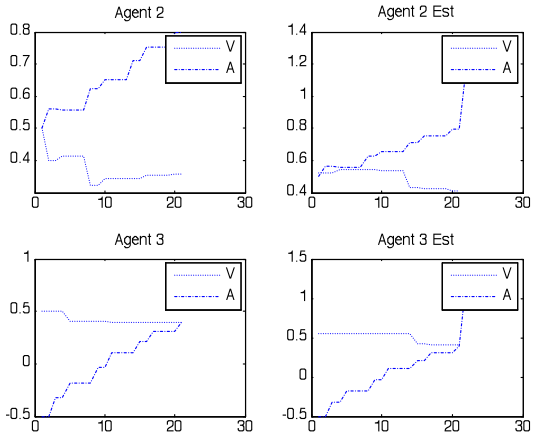

Figure 5: Emotional evolution of Agents 2 and 3

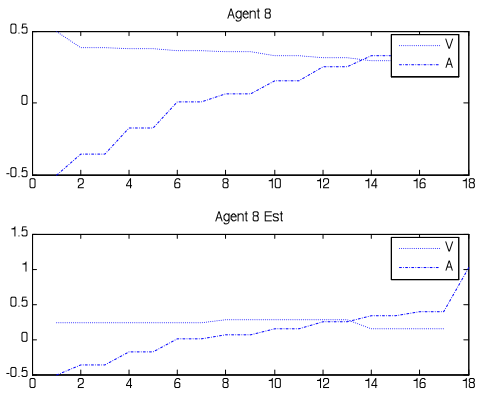

Figure 6: Emotional evolution of Agent 8 as it wrote "quiet"

9 CONCLUSIONS AND FUTURE WORK

MASTER is the first multi-agent system approach for computer-aided creation of poetry and, as far as we are aware, the first generative poetry system utilizing artificial emotion. This combination of social interactions and emotional dynamics allows the system to avoid all random processes, which are often required by creative systems [21]. The creativity emerges as a

result of the complex interactional dynamics. The resulting texts are not meaningful in the normal sense - the sound and word repetition generates meaning. Like normal English, there is actually a hierarchical structure to the repetition (i.e. repetitions within repetitions), and the words are often evocative and sometimes contrasting.

There are a number of key areas which would benefit from further work. One is the emotional estimation system. In particular the arousal detection system utilizes ideas which need to be more fully tested, perhaps by perceptual studies. Furthermore the emotional estimation system is only on a word level. Emotion is generated by text through the cumulative effect of many words, phrases, stanzas and so forth. MASTER has no embedded sense of this process. For example a phrase made up of 3 happy words and 3 sad words is not necessarily emotionally neutral. In fact in many cases there may be little correlation between the emotive effect of a stanza and the emotive effect of its individual words.

Even though MASTER is not designed to write sentences, it would benefit from a clearer "understanding" of language structure. Emotional impact may be increased if the orderings of words in a MASTER text are a little more reminiscent of normal writing. Or at the very least it would be useful tool to have a parameter that allowed this to be implemented. Such a method could involve simple statistical models of word orderings, and an agent only adding text to the end of its own text if there is a sufficient statistic likelihood of such word orders.

Despite these limitations it is hoped that MASTER indicates the potential for the use of affective computing in generative poetry, and additionally indicates the potential of multi-agent systems in this field.

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