Shades of Computational Evocation and Meaning: The GRIOT System and Improvisational Poetry Generation

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ABSTRACT

GRIOT is a computer program developed to implement systems that output interactive computational narratives. The first systems built in GRIOT allow improvisational generation of poetry in response to user input. The system is based on an approach to computational narrative that builds on research from cognitive linguistics on metaphor and conceptual blending, socio-linguistics on how humans structure narrative, computer science on algebraic semantics and semiotics. This paper is a report on the GRIOT system. Foundational theories are discussed, the GRIOT architecture is outlined, and examples of output from a poetic system are presented and explained. The central idea is that for narrative computational media artwork, values of subjective meaning and evocative expression are inseparable from the formal technical means used to produce them. Despite the use of formal descriptions of semantic concepts, meaning must be understood as contextual, dynamic, and embodied, and implementations of computational narrative systems should reflect this.

Keywords

computational narrative, algebraic semiotics, metaphor theory, conceptual blending theory, optimality principles, subjective meaning, poetry

1. Introduction

> *she began her days looking in the mirror at her own awe and contradiction face*
>
> *as she grew older she saw privilege, prejudice wrinkles upon her face*
>
> *and feared only wintery-skin of feathers*
>
> *she peeped out sunbather and horned-haint cries*
>
> *she looked to the sky and knew cloudy guillotine days would end*
>
> – output from an execution of "The Girl with Skin of Haints and Seraphs," a poetic system implemented using GRIOT

Within American culture there exist familiar depictions where Pan-African spiritual traditions such as Haitian Vodou or Brazilian Candomblé are presented as "evil." For example, the trickster Orixá Exu is conflated with the devil in some persecutorial Christian ideologies. By the same token, there exists within some African based cultures the notion of the "white devil," or technology as the "unnatural fruit of Babylon." Demonization occurs from both sides of the dialectic, though power distribution is not equitable between them. Tales of miscegenational diabolic power are common in contemporary cultural media as diverse as film, comics, popular music, and computer games: human mothers gave birth to Dante, the son of the demon knight Sparda in Capcom's *Devil May Cry* games series [9], Alucard (Dracula reversed) the son of Dracula in Konami's *Castlevania* game series [8], and Blade, the jazz trumpet playing vampire hunter whose blood was tainted by a vampire's feasting on his mother at birth in Marv Wolfman's *Tomb of Dracula* comics series [40]. In the 1980's the Rastafarian hardcore/punk rock group *Bad Brains* described themselves as "Fearless Vampire Killers" as their singer intoned [4]:

> The bourgeoisie had better watch out for me. All throughout this so-called nation, we don't want your filthy money, we don't need your innocent bloodshed. We just wanna end your world. Well my mind's made up. Yes, it's time for you to pay, better watch out for me. I'm a member of the F.V.K..

Imagery from the dark romance genre edged up against issues of identity, social inequity, and cultural misrepresentation is a trope with a long history.

These are considered sensitive sociological and humanistic issues, more rarely are they considered cognitive issues, but seldom would anyone consider them *computational* issues. This paper is about computational techniques suitable for representing subjective meaning and expression such as the thoughts in the paragraph above. Special attention is given to the use of these subjective representations in interactive and generative narrative artwork. This requires that concepts be formalized in a manner amenable to algorithmic generation, composition, media representation, and manipulation via user input, but also with strong socio-cultural grounding. A strong socio-cultural grounding here implies that despite the use of formal descriptions of semantic concepts, meaning is considered to be contextual, dynamic, and embodied [38].

GRIOT can be used as a framework to implement systems to generate poetry line-by-line in response to user feedback. The first poetic system created using GRIOT is entitled "The Girl with Skin of Haints and Seraphs" and generates prose poems about a girl with skin of angels and demons in response to user input about domains such as Europe, Africa, girls,

whiteness, devils, and angels. A poetic system is not the individual output of one execution of GRIOT, but rather the code that generates many instances of poetic output algorithmically, while maintaining core concepts and themes, with meaning emerging from the differences between the varying output poems. The system's output represents a subjective and transitory notion of identity. The GRIOT architecture is based in computer science and mathematics (algebraic semantics and specification), in addition to semiotic and cognitive linguistics approaches to theorizing conceptual representation and blending.

The following outlines the contents of this paper. Section 2 describes GRIOT's theoretical framework developed at the UCSD Meaning and Computation Lab. Specifically, section 2 presents a discussion of metaphor theory and conceptual blending theory from cognitive linguistics and algebraic semiotics which uses algebraic semantics to describe complex signs structures and the blending of such structures [15]. Section 2 concludes with a discussion of narrative, focusing on an empirical sociolinguistic model of narrative and a brief commentary on broadening the cultural scope of computational narrative work.

Section 3 discusses how ALLOY (an algorithm I implemented for conceptual blending) and GRIOT use the theoretic basis described in section 2. In 3.1, related and influential precursors are discussed. 3.2 presents a detailed outline of how the GRIOT system functions. 3.3 presents the poetic system developed using GRIOT entitled "The Girl with Skin of Haints and Seraphs" and sample output from the system.

Section 4 concludes the paper with a discussion of the system as a cultural object in society and the integration of artistic, socio-cultural, technical, and artistic methodologies in the work described here. The upshot is that though discussion of demons, whiteness, and seraphs may be alien within technical research, the inclusion of such issues in the introduction was not meant merely to be provocative. Serious consideration of expressive content as inseparable from issues of formalization, procedural art, and technical implementation is necessary for the development of interactive narrative artwork and critical technical practices [2] that hold creation of evocative, socially situated, and perhaps even *emotionally moving* story worlds and user experiences as goals.

2. FOUNDATIONS

Subjective meaning and computation are usually seen as completely separate issues. Traditional "good old fashioned AI" work in knowledge representation, expert systems, semantic networks, and other well-known projects focused on complete and correct formal descriptions of domains to allow shared knowledge bases for making inferences. Though domains themselves may have encoded specific bodies of knowledge, within particular domains comprehensive global understanding was a goal. The results were systems with narrow expertise and the characteristic that "to solve a problem you almost have to know the answer already [35]. An early example of such a project was the blood infection diagnosis expert system MYCIN developed at Stanford University in the 1970's by Ed Feigenbaum, Bruce Buchanan, and Edward Shortliffe [35]. MYCIN produced successful diagnoses in a specific domain based upon rules (including certainty factors) acquired through extensive interviewing of experts. Dynamic, subjective meanings (both culturally entrenched and idiosyncratic) and surprising, novel inferences have not been traditional foci of inquiry in artificial intelligence research. However, for computational narrative artworks and investigation of narrative human thought, such semantics are crucial areas of inquiry. A useful account of these issues is provided by research in cognitive linguistics: metaphor theory and conceptual blending theory investigate human concepts, mappings between them, and their role in everyday thought.

2.1 Metaphor Theory and Conceptual Blending Theory

Key insights from the cognitive linguistics enterprise include foregrounding that mental activities such as metaphorical reasoning, narrative understanding, and blending of concepts are constant and usually unnoticed, as opposed to being only higher level literary processes [37]. George Lakoff, Mark Johnson, and others [25] have studied metaphor as mappings from one conceptual space to another, and have shown that there are many basic, entrenched metaphors that people use to express everyday concepts. These concepts are structured by image schemas, "skeletal patterns" that recur in our motor-sensory experiences such as Motion Along a Path, or More is Up as expressed respectively by metaphors such as "life is a journey" (a basic metaphor), "consciousness raising," or even combined in the phrase "movin' on up." Metaphor theorists propose that understanding of many basic abstract concepts relies upon metaphorical thinking and analogy, and that metaphorical thinking arises from a basis in embodied human experience of the world [38].

Gilles Fauconnier and Mark Turner's conceptual blending theory [12] describes the means by which concepts are integrated, guided by "uniform structural and dynamic principles" both unconsciously in everyday thought and in more complex abstract thought such as in literary arts or rhetoric. A basic component of the theory is a conceptual space. Conceptual spaces, building upon Fauconnier's theory of mental spaces [11], are sets of "elements" and relations, "relatively small, transient collections of concepts, selected from larger domains for some purpose at hand, such as understanding a particular sentence [17]." Although concepts are often viewed as packets of meaning, really they arise from connections across multiple meanings that are dynamic and distributed. Conceptual blending theory builds upon insights from metaphor theory. Metaphoric blends are asymmetric in that one space, the "target" of the metaphor, is understood in terms of the other "source" space [20]. For example, in the phrase "the sun is a king" aspects of "king" are "blocked" from mapping to the blend space – usually the sun does not wear a crown or charge taxes. Conceptual integration networks are networks of conceptual spaces and conceptual mappings used in blending the component spaces for situations that are more complex than a single metaphor.

The basic elements of a conceptual integration network are [12]:

1) Input Spaces (the conceptual spaces to be combined)
2) Cross-space mappings (links between analogous elements in different input spaces)
3) The Generic Space (a conceptual space mapped to both of the input spaces that describes shared structure between the input spaces)
4) The Blended Space (the space in which elements from the input spaces are integrated)

Fauconnier and Turner assert that the process of blending is structured by sets of "constitutive" (the structure and process described above) and "governing" principles that exert pressure to produce optimal blends. These governing principles optimize emergent structure in the blends all "other things being equal."

Five principles that Fauconnier and Turner [12] give to characterize optimal blends are:

1) Integration: The scenario in the blend space should be a well-integrated scene.
2) Web: Tight Connections between the blend and the inputs should be maintained, so that an event in one of the input spaces, for instance, is construed as implying a corresponding event in the blend.
3) Unpacking: It should be easy to reconstruct the inputs and the network of connections, given the blend.
4) Topology: Elements in the blend should participate in the same kinds of relation as their counterparts in the inputs.
5) Good Reason: If an element appears in the blend, it should have meaning.

All these require human judgment, and cannot be implemented in any obvious way. However the Topology Principle, in the special case where the relations involved are identities, does not involve meaning, and so can be implemented; indeed, it is part of the ALLOY conceptual blending algorithm discussed in Section 3.2.

A computational model of blending theory can be used to build models for concept generation within computational narratives. In order to be implemented it needs to be given a precise notation. Formalizing some notions from cognitive linguistics does not entail believing that formal structure alone can account for imaginative thought. On the contrary, it is hoped that a precise notation can aid in clear thinking about dynamic and contingent processes. The modest claim made here is that precise notation can aid in empirical testing and clarity of discussion about these theories, and in implementing these ideas for artistic (and other) pursuits. Algebraic semiotics can be used for these purposes.

2.2 Algebraic Semiotics

On a cursory glance, the use of traditional semiotics for computational sign production and analysis has been surprisingly controversial considering its popularity for analyses of other media such as literature or film. The critique of the utility of semiotics for analysis of computational signs is well-founded for reasons including: the failure of traditional semiotic theories to account for the dynamic nature of computational signs, the nature of the computer as a metamedium (it can replicate and integrate previously disparate media), and the separations between models of computation, actual code, instantiated implementations, and human perceived effects of executed code. Computational text and game studies theorist Espen Aarseth summarizes the situation as follows [1]:

> The main problem seems to be the assumption that cybernetic sign processes can be understood and classified by observing their surface expressions alone. When the relationship between surface sign and user is all that matters, *the unique dual materiality of the cybernetic sign process is disregarded.* Without an understanding of this duality, however, analysis of cybernetic sign production become[s] superficial and incomplete.

The "dual materiality" Aarseth refers to is the split between code and its expression. He observes that "two different code objects might produce virtually the same expression object, and two different expression objects might result from the same code under virtually identical circumstances." The first of these observations is correct and well-known in computer programming, the second is ambiguous because it is not clear what constitutes "virtually identical circumstances[1]."

Algebraic semantics can help this situation. Algebraic semantics is used to describe the semantics of code behavior by a set of axioms with purely syntactic properties. It is especially elegant for capturing behavior of abstract data types [19]. Algebraic semiotics uses formalizations from algebraic semantics in addition to insights from Saussurean and Peircian semiotics [15], and cognitive linguistics. It has been used to address precisely the concern that Aarseth raises: in user-interface design algebraic semiotics has been used to express mappings between specifications and representations, to consider traditional graphical representational structures, and has the additional benefit of being precise and amenable to implementation. Algebraic semiotics is a new and developing approach, but I believe that modest successes such as the implementation of an algorithm for conceptual blending and rigorous and useful analyses of user-interface design are signs that it is a promising theory [15].

[1] In *exactly* the same circumstances it is false. "Exactly" is a controversial idea as well since it is impossible in reality to replicate exactly the same circumstances at two different times, though we can clarify the situation be defining "exactly" by restricting it to computational models, e.g. mathematical execution of two identical Turing machines at two different times.

In algebraic semiotics the structure of complex signs, including multimedia signs (e.g., a film with closed captioning), and the blending of such structures are described using semiotic systems (also called sign systems) and semiotic morphisms. A sign system consists of [17]:

> a loose algebraic theory composed of type declarations (called sorts) and operation declarations, usually including axioms and some constants), plus a **level ordering** on sorts (having a maximum element called the **top sort**) and a **priority ordering** on the constituents at each level. Loose sorts classify the parts of signs, while data sorts classify the values of attributes of signs (e.g., color and size). **Signs** of a certain sort are represented by terms of that sort, including but not limited to constants. Among the operations in the signature, some are **constructors**, which build new signs from given sign parts as inputs. Levels express the whole-part hierarchy of complex signs, whereas priorities express the relative importance of constructors and their arguments; social issues play an important role in determining these orderings. Conceptual spaces are the special case where there are no operations except those representing constants and relations, and there is only one sort. Many details omitted here appear in [15].

A semiotic morphism is a mapping between sign systems. One very useful type of mapping discussed above is that between a data structure and a graphical visualization of that data. Another is a mapping between a sign system describing functionality and content. These types of morphism are useful for analysis of representations in user interface design, but also in generation of sign systems such as in the ALLOY algorithm. For the purposes here we are interested in formulating morphisms so that they can be manipulated algorithmically. A semiotic morphism maps sorts, constructors, predicates and functions of one sign system to sorts, constructors, predicates and functions of another sign system respectively. Blending maps several conceptual spaces together using several semiotic morphisms. Typically it is useful to consider a most basic type of blend that involves a generic space and two input spaces that each get mapped to a target, or blend space.

Algebraic semiotics and blending alone are useful for content generation, Section 3 will explain how an algebraic semiotic representation of blending is used for interactive poetry generation with the GRIOT system, and how narrative can structure content for use in expressive artworks.

2.3 Narrative

In cognitive linguistics theory we have seen that metaphor and the ability to rapidly invent new ideas are fundamental to human cognition. Narrative is also fundamental to human communication and narrative discourse is one of the most basic methods we have of structuring our own thoughts, understanding those of others, and more broadly entrenching ideas within society. In interpersonal communication such as speech, narrative is negotiated between individuals. It is highly nuanced, improvisational, contextual, and interactive. In other media such as writing, film, or radio narrative works lose their interactive and negotiated character as they gain other characteristics such as reproducibility, material persistence, or the ability to be transmitted over a distance. Computational media have their own specific characteristics such as abstract data structures, dynamic execution, polymorphic representation, user feedback channels, distributed networks, and massive storage. I believe that powerfully evocative new narrative forms can be constructed to take advantage of these unique characteristics of computational narrative. But is narrative structure amenable to computational representation, and if so what would such a narrative structure look like?

There are many accounts of narrative, both formal and informal: Propp's morphology of the Russian folktale [32], Gerard Genette's structuralist narratology [14], Henry Louis Gates Jr.'s account of signification in African and African American literature [13], Gerald Vizenor's account of non-causal narratives in the Chippewa oral tradition [39], and many more. A goal in the development of the GRIOT system was to develop a general architecture upon which narrative structures derived from a variety of narrative models could be implemented. For the practice of poetic text generation, a useful model of narrative has been that of William Labov's sociolinguistics based account of oral narratives of personal experience where the narrator is an agent in the story [25]. This model of narrative has been useful for several reasons, it is simple and easily extensible to generate other than personal oral narratives, it has an empirical basis, it includes and account of "values" occurring within the narratives, and it has been formalized by Joseph Goguen [16].

The discourse structure of narratives of personal experience, the result of work by William Labov [25], as refined by Charlotte Linde [28], can be summarized as follows [16]:

> 1) There is an optional orientation section, which gives information about the time, place, characters, etc. in what will follow.
>
> 2) The main body of the narrative consists of a sequence of narrative clauses describing the events of the story; by a default convention, called the narrative presupposition, these are taken to occur in the same order that they appear in the story. The narrative clauses are usually in the past tense.
>
> 3) The narrative clauses are interwoven with evaluative material, which provides interpretative or evaluative information, i.e., which relates the events to the narrator's value system, which by default is presumed to be shared with the audience. Evaluative material often appears in separate clauses, but it may also take the form of repeated words, unusual syntactic or lexical choice, etc.
>
> 4) There is an optional closing section, which

summarizes the story, or perhaps gives a moral.

This structure was implemented almost directly for use within the first poetic systems created using the GRIOT architecture.

In addition to Labov's narrative of personal experience, the GRIOT constructed poetic system "The Girl with Skin of Haints and Seraphs" invokes attributes of other culturally specific narrative forms. Dynamic improvisation and call and response structures are familiar aspects of Pan-African narrative forms as diverse as the African Brazilian martial art and dance Capoeira Angola, Charles Mingus's calling out of the segregationist Governor of Arkansas in "Fables of Faubus [29]," the penetratingly satirical fiction of Ishmael Reed, and hip-hop freestyle rhyming. Written prose poetry [27], and its more recent descendant flash fiction [36] ("short short" stories that encapsulate full narrative arcs within extremely abbreviated word counts), traditionally have not incorporated these techniques. On-the-fly improvisation has not been incorporated for the simple reason that the nature of medium of printed text is not dynamically reconfigurable. Computational media have dynamic information structure and feedback loops built into the nature of the medium. The output of "The Girl with Skin of Haints and Seraphs" combines this type of prose poetry, dynamically reconfigurable and founded in African and African American vernacular traditions of signification [13].

3. THE GRIOT SYSTEM

The project of narrative generation has a history in computer science, digital art, and electronic literature, with different artists and researchers adopting different goals, philosophical stances, and techniques. GRIOT is unique in its combination of the following attributes:

- it represents semantic "deep structure [5]" using conceptual blending theory and algebraic semiotics
- it has a solid theoretic basis in cognitive linguistics, it uses a computational model of conceptual blending that I implemented (called ALLOY)
- it is not framed as an answer to a "poetry generation Turing test," rather the system itself is the cultural product and the variable differences between its output are key aspects of subjective meaning
- it is flexible enough to represent diverse cultural models of narrative
- it has been used to implement a system that attempts a synergy between evocative metaphor, sociological commentary, and formal semantics

These unique aspects of the system can be understood better by briefly reviewing several other examples of important work in this area.

3.1 Related Work

An early relevant work is Raymond Queneau's 1961 "Cent Mille Milliards de Poémes" ("One Hundred Thousand Billion Poems") [33], originally published as a set of ten sonnets with interchangeable lines, but later made available in computer implementations. This work is relevant because of its exploration of the idea of writing as a combinatorial exploration of possibilities, which exemplifies the experimental literary group Oulipo's often whimsical use of mathematical ideas. This view well explicated by another Oulipo member, Italo Calvino, in his essay/lecture "Cybernetics and Ghosts [7]." Calvino claims that writing is a combinatoric game and cites work such as Vladimir Propp's morphology of the folktale to support his thesis [32]. Calvino states "the operations of narrative, like those of mathematics, cannot differ all that much from one people to another, but what can be constructed on the basis of these elementary processes can present unlimited combinations, permutations, and transformations." In Calvino's novels such as "If on a winter's night a traveler" there was also a strong sense of narrative coherence and a concern for a careful balance between experimental form and meaningful expression. The GRIOT system is more influenced by this concern for coherent subjective expression in Calvino's work than merely the idea of utilizing mathematical techniques to arrive at poetry with variable structure for its own sake.

A classic earlier example of this concern for ways in which subjective meaning can emerge from experimental literary structure is Ryunosuke Akutagawa's 1922 short story "In a Grove" (and Akira Kurosawa's famous film adaptation "Rashomon") [3]. "In a Grove" is the tale of a brutal rape and murder told and retold from a variety of perspectives: from the vantage point of the victims, the perpetrator, and a by-stander. Meaning is constructed through the concrete knowledge that the event did take place and the shifting, conflicting reports of the event given by the characters. The conflicts between the different points of view are used to create an emergent statement about the human condition and the absence of truth as exemplified in the following dialogue from Kurosawa's film *Rashomon* [24]:

> Priest: If men don't trust one another, then the earth becomes a hell.
> Commoner: Right. The world's a kind of hell.
> Priest: No! I don't want to believe that!
> Commoner: No one will hear you, no matter how loud you shout. Just think. Which one of these stories do you believe?
> Woodcutter: None makes any sense.
> Commoner: Don't worry about it. It isn't as if men were reasonable.

In the hands of a careful poetic system implementer GRIOT provides a means to make use of "meaningful difference" between output to allow a global meaning to emerge from repeated execution of the system.

In addition to the examples from literature and film there are diverse computational examples. Influential systems from the field of computer science include Meehan's Talespin [29], Scott Turner's MINSTREL [6], and Bringsjord and Ferrucci's BRUTUS [6]. It is useful to contrast the differences between Talespin as an example of an early system and BRUTUS as an example of a more recent system. Meehan's 1976 Talespin is perhaps the first computer story generation system. It produced simple animal fables, with the goal of exploring the

creative potential of viewing narrative generation as a planning problem, in which agents select appropriate actions, solve problems within a simple simulated world, and output logs of their actions (which are not generally effective as interesting stories). Selmer Bringsjord and David Ferrucci's 2000 BRUTUS system aims to explore formalizations for generating stories about betrayal, with the goal of being "interesting" to human readers. While Talespin directly exposed a reader to the output of a planning algorithm, BRUTUS uses rich textual descriptions. For example a university is an object implemented with both positive iconic features: {clocktowers, brick, ivy, youth, architecture, books, knowledge, scholar, sports} and negative iconic features: {tests, competition, 'intellectual snobbery'}. As a goal, Bringsjord and Ferrucci seek a type of storytelling Turing test competence, but avoid claims that the system actually authored the texts.

In contrast to those computer science based systems, William Chamberlain and Thomas Etter's dialogue based program Ractor, and Ractor's (Chamberlain's) 1984 book, *The Policeman's Beard is Half Constructed* [34], used syntactic text manipulation to support conversation with users having text input and poetic output. This was not intended as scientific research, but rather as entertainment, with humorous clever output. Unlike Bringsjord and Ferrucci, Chamberlain described such output as being computer authored, exploiting the novelty of being "written by a computer program." Many text generation projects have been oriented towards total automation and Turing test competence. The goal with GRIOT was quite different: it is designed to provide a technical framework for humans to provide rich content and poetic systems created with GRIOT are meant as cultural products themselves (as opposed to instances of output of such poetic systems). Charles Hartman's 1996 work in automated poetry generation [23] was presented as literary experimentation, but Hartman realized that it is better not to ask "whether a poet or a computer writes the poem, but what kinds of collaboration might be interesting." Hartman's work emphasizes how a computer can introduce "randomness, arbitrariness, and contingency" into poetry composition. This is another significant difference from the GRIOT system which uses structured principles of meaning and narrative to guide poetry generation as opposed to random template selection.

A final influential work in richer media and developed as a joint enterprise of documentary filmmaking, computational media art, and artificial intelligence is *Terminal Time* developed by Steffi Domike, Michael Mateas, and Paul Vanouse at Carnegie Mellon University [10]. In *Terminal Time* an audience is polled in real-time with questions about the state of society today and on the fly a "Ken Burns style" documentary of the last two millennia of history is created to attempt to mirror and often exaggerate their biases and desires." Its basis in what Michael Mateas terms "expressive AI" allows *Terminal Time* to utilize formal representations subjective meaning. Like *Rashomon*, *Terminal Time* invokes "meaningful difference" as a central strategy for artistic expression and is an important example of computational art because computational (artificial intelligence) concerns are intertwined with expressive content: recombinable content structure and shifting rhetorical differences along with the technology used to produce them are central to the work. GRIOT has similar concerns as *Terminal Time* in this respect. A novel contribution of the GRIOT system to this type of work is its theoretical underpinnings and contributions to research in the frameworks of algebraic semiotics and cognitive linguistics.

3.2 The GRIOT Implementation

Based on the theory for section 2, the GRIOT implementation has the following components [17] [18]:

1) Theme Domains: Themes are represented by axioms expressing properties specific to that particular poetic system. Associated with each theme domain is a list of keywords that access that theme domain.
2) The ALLOY Conceptual Blending Algorithm: The blending algorithm generates new concepts and metaphors from input spaces selected from the theme domains.
3) Grammar Morphism: This maps conceptual blends to representations in natural language.
4) Optimality Principles: GRIOT uses structural optimality principles based upon those from conceptual blending theory (Fauconnier and Turner). The implementation of these principles are detailed in [16]. They consist of a metric that quantifies optimality according to: (1) commutativity of mappings from elements in the input spaces to the blended space (see [15] for details), (2) changes of type of elements in the input spaces, and (3) the number of elements from the input spaces that are preserved in the blended space.
5) Narrative Structure: This defines how phrase templates can be composed. A poetic system designer inputs her or his choice of narrative structure; initial experiments used a version of the Labov narrative structure of personal experience. The templates are selected using a new type of automaton that we call a "probabilistic bounded transition stack machine."

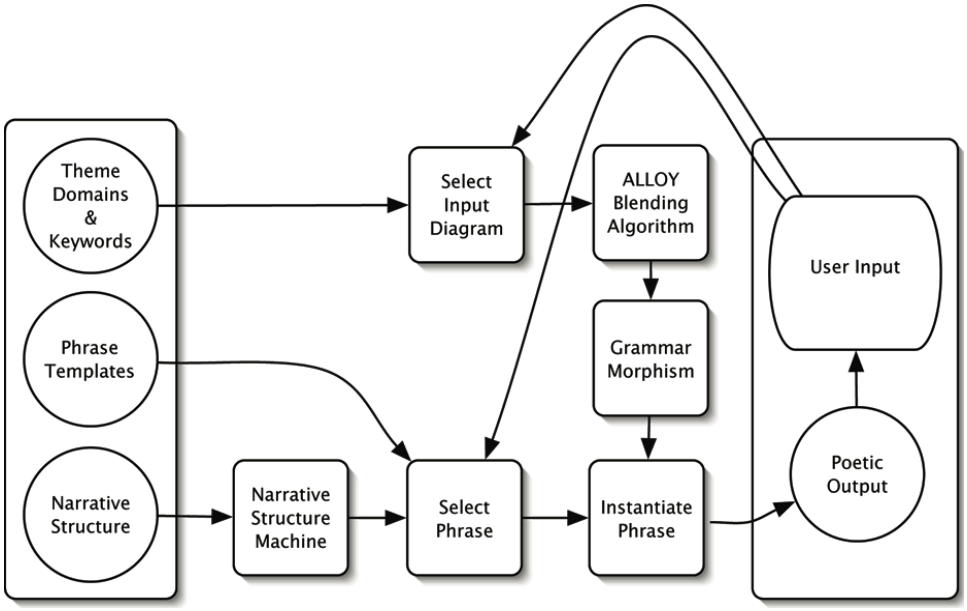

Figure 1. The GRIOT architecture.

Using these components, the GRIOT system functions as follows:

1) Formatted input is read in and the system is initialized. This input consists of the theme domains and keywords, phrase templates, and a narrative structure, provided by a poetic system designer.

2) An Input Loop begins, the system waits for user input in the form of a keyword (later this could be a multimedia event).

3) A phrase, of the appropriate type, is selected from the list of phrases. A phrase is a line of text represented as a list such as "(Her dreams were (* g-singular-noun) or (* g-verb-clause))." The phrase type is decided by the narrative structure provided as a finite state automaton, or more generally a probabilistic pushdown automaton.

4) The phrase selected in (2) is checked for wildcards of the following types:

   - *p = phrasal (used to select a particular phrase type in order to replace the wildcard with a subphrase)
   - *g = grammatical (used to choose grammatical expression for a blend-space, this would be bolstered for richer media)
   - *d = domain (used to select domain)
   - *a = axiom (for finer grained conceptual space selection)

   A grammatical wildcard consists of a token to represent its grammatical type, and possibly additional tokens to indicate the domain that should be used to replace it. For each wildcard two domains are selected to be blended. This selection is either random, specified by the wildcard itself, or according to user input provided in (1).

5) Conceptual spaces are selected from the chosen domains as follows:

   5.1) Axioms are chosen from the first domain. An axiom is a relation represented as a list such as "(axiom "devours" ((constant "evil" "emotion" demons-space 0) (constant "hope" "emotion" demons-space 0))." The "0's" are used in computing the blend optimality.

   5.2) A subdomain is formed from the second domain that consists only of axioms of sorts that match the chosen axioms, axioms are selected randomly from the subdomain.

   5.3) These spaces are used to create an input diagram (the generic space, two input spaces, and morphisms between the spaces).

   5.4) The input diagram is passed into the blending algorithm, which outputs a conceptual blend and two morphisms to it.

6) The wildcards are replaced using the output conceptual blend. To replace a wildcard, a grammar morphism, implemented as a hash table of closures, is consulted. For each wildcard type it provides a mapping from a conceptual blend to a grammatical (later this could be another medium) form.

7) The phrase is output with all wildcards replaced, the phrase is said to be instantiated.

8) The Input Loop starts over, unless the system has reached a finish state in the narrative structure.

3.3 A Poetic System

Once again, "The Girl with Skin of Haints and Seraphs" is a GRIOT based poetic system that outputs prose poetry about a girl with skin of angels and demons in response to user input about domains such as Europe, Africa, girls, whiteness, devils, and seraphs. The system's output represents a subjective and transitory notion of identity. The following are four instances of output intended to provide a sense of both the variability and thematic coherence of the output, and the manner in which user input affects the output.

(1) The first sample poem and a detailed description of its generation follows. User input is differentiated by being preceded by a '>' prompt. The system output is italicized. My commentary on how some of the content of each line of text is generated follows the system output. LISP code for an axiom describing subjective information about the domain follows my commentary.

> her arrival onto this earth was marked when first-born and charcoal-girl transforms to impoverished-elder or charcoal-woman
>
> she worked raising snow-queen original-lady children of her own
>
> the young lady would prevail
>
> a caress across her skin scares up demon black
>
> her failure was ignoring her wings and original-lady nature
>
> and she felt glad
>
> as she grew older she saw entitlement defiance wrinkles upon her face
>
> ebony-wood-like brimstone defines fetish bedrock, the sign that let her know she finally really alive

>Africa

(her arrival onto this earth was marked when first-born and charcoal-girl transforms to impoverished-elder or charcoal-woman)

The concepts of first born people, the impoverished elder, and charcoal skin are selected from the 'Africa' domain in this opening clause. The LISP axiom selected for blending is:

```
(axiom "is-now"
  ((constant "first-born" "person" afrika-space)
   (constant "impoverished-elder" "person" afrika-space)))
```

>Europe

(she worked raising snow-queen original-lady children of her own)

The concept of the snow queen is selected from the 'Europe' domain in this narrative clause. The LISP axiom selected for blending is:

```
(axiom "wears"
  ((constant "snow-queen" "person" europe-space)
   (constant "wintery-skin" "object" europe-space)))
```

>demon

(the young lady would prevail)

The 'Demon' domain is selected, but not used in this evaluative clause.

>demon

(a caress across her skin scares up demon black)

The concept of a demon is selected from the 'Demon' domain in this narrative clause. The LISP axiom selected for blending is:

```
(axiom "stokes"
  ((constant "demon" "person" demons-space)
   (constant "hate" "emotion" demons-space)))
```

>angel

(her failure was ignoring her wings and original-lady nature)

The concept of wings is selected from the 'Angel' domain in this evaluative clause. The LISP axiom selected for blending is:

```
(axiom "covered-with"
  ((constant "wings" "person" angels-space)
   (constant "feathers" "object" angels-space)))
```

>black

(and she felt glad)

The 'Africa' domain is selected, but not used in this evaluative clause.

>white

(as she grew older she saw entitlement defiance wrinkles upon her face)

The concept of entitlement is selected from the 'Europe' domain for use in this narrative clause. The LISP axiom selected for blending is:

```
(axiom "experiences"
  ((constant "european" "person" europe-space)
   (constant "entitlement" "sensation" europe-space))
```

>juju

(ebony-wood-like brimstone defines fetish bedrock, the sign that let her know she finally really alive)

The concept of an ebony wood fetish is selected from the 'Africa' domain in this closing clause. The LISP axiom selected for blending is:

```
(axiom "constructs"
  ((constant "ebony-wood" "object" afrika-space)
   (constant "fetish" "object" afrika-space)
```

(2) The following is output produced when user input selects the use of the 'Europe' domain for constructing conceptual spaces for blending.

>Europe

her tale began when she was infected with white female-itis

>Rome

she worked raising bullet, spiked-tail children of her own

>Norway

in the shadows

>Greece

when she was no longer a child peasant, august-being marks streaked her thighs

>Europe

her barbarian, impoverished-elder spirit would live on

(3) The following is output produced when user input selects the use of the 'Europe' domain for constructing conceptual spaces for blending.

>Europe

europeans and beauty relish, create entitlement and cool ringing in the ears of the girl with skin of smugness and kindness blended with neck, red

>Europe

she worked raising imperialist, cherub children of her own

>Europe

death was better

>Europe

her spirit trusts that a nordic-beauty or epidermis arouses,

provokes awe desire

>Europe

a spectral tone pervaded

>Europe

sunbather and first-born envies and is now melaninated and impoverished-elder, causing her eyelids to droop

>Europe

she knows that childish reverence of contradiction days will fall further and further behind

(4) I conclude with a poem with generated content derived from blending concepts from the 'Skin' domain with concepts selected by the system.

>skin

she began her days looking in the mirror at her own pale-skinned death-figure face

>skin

she peeped out shame, hate

>skin

finally she fell from a cloud and skin and black drenched days were left behind

4. CONCLUSIONS AND FUTURE WORK

The GRIOT framework was developed with multiple goals in mind. A longer term goal is generalizing the technical and theoretical framework developed in GRIOT to support interactive computational narratives with richer media such as animation or sound [18]. Toward this goal, a simple extension is passing user input to the system via a graphical or game-like interface (for example navigating a game map or selecting objects in a virtual environment). In a piece entitled "The Griot Sings Haibun" the system has been used with a graphical interface (depicted in **Figure 2**) to generate "(neo)haibun," a combination of prose, haiku, and beat poetry that is often used to narrate personal everyday experiences in a live performance with free jazz musicians [22]. A more complicated extensions is to use blending to generate new graphical or audio content on the fly. In practice it will require new and efficient blending algorithms and data representations as well as extension of the theory to account for non-linguistic input. One approach is to use conceptual spaces as metadata to annotate graphical information, blending the metadata, and providing morphisms from these annotations to graphical representations. This is a promising future extension for this work.

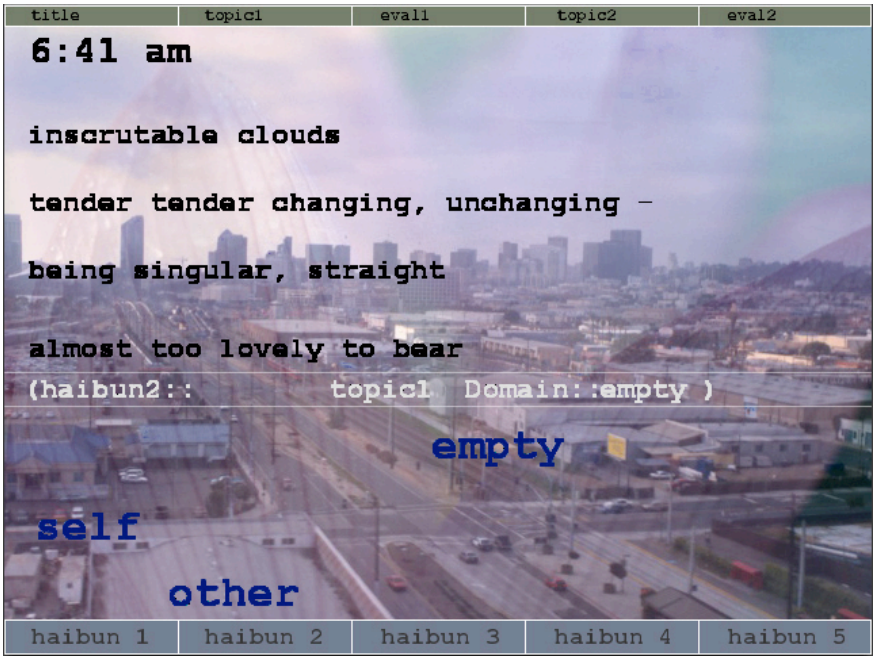

Figure 2. "The Griot Sings Haibun" graphical user interface

The immediate goal of the GRIOT system is itself multi-faceted. Poetry generation guided thematically by user input is an initial experiment used to investigate the use of ALLOY (specifically the algebraic semiotics based optimality principles) for content generation. The experiment is multi-disciplinary and we were concerned with the following: the results had to be artistically expressive such that the procedural nature of the medium informed the meaning of the work and its grounding in social context, the model had to be consistent with principles and results of conceptual blending theory, the conceptual blending algorithm had be efficient, and the model had to be implemented using the algebraic semiotics framework. The initial computer science goals have been met: a new data structure for input spaces was developed and the ALLOY algorithm is efficient (output poetry is generated in milliseconds). Progress has also been made on the cognitive science goals, though there are many outstanding issues. For reasons discussed above we implemented only a subset of Fauconnier and Turner's optimality principles. Using sign systems from algebraic semiotics means that some structure from Fauconnier and Turner's conceptual integration networks was omitted (most notably cross-space mappings), while some structure was added (most notably sorts). Accounting for the various cross-space mappings in conceptual blending theory and implementing further structural optimality principles are important future research projects. Still, for several small conceptual integration networks our implemented optimality principles have resulted in generation of appropriate optimal blends. A surprising result was that for poetry, as opposed to "common sense" blending, it seems that different sets of optimality principles are required for the algorithm to result in radically unexpected blends.

Artistic "goals" are, of course subjective, and of a different nature than the scientific agenda. In a sense, viewing the system as a cultural product provides a more clear lens for analysis because it does not require artificial subdivision of the work according to disciplinary boundaries. The mathematical, computational, cognitive, and expressive elements of the system are completely integrated with specific subjective content. For example, universal algebra as a "science of arbitrary signs [31]" contributes to cultural identity theory, computational poetry is implemented based upon algebra, and a notion of dynamic social identity inspired the architecture for a set of dynamically generated poems. Angels, demons, vampires, imperialists, winter skin, griots, and trickster spirits, can infiltrate computational work not as metaphorical asides, but as representatives of the conviction that, for computational narrative artwork, subjective meaning and technical implementation are inseparable. In this regard I view the system as a success – I believe these diverse interests have finally formed a coherent whole. But the title of this paper includes the word "evocation" because I seek computational work that evokes imaginative metaphor, emotional affect. While I can attest that the process creating the work provided strong such effects for me, it is but a wish that readers such as yourself will share this feeling.

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