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The Shape of Story: A Semiotic Artistic Visualization of a Communal Storytelling Experience

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Abstract

Telling stories is a central part of human culture. The development of computational systems that can understand and respond to human language is an integral part of AI research in general and narrative technologies in particular. In this paper, we describe a system that is able to understand human spoken English sentences and portray that understanding via a semiotic visual language in real-time. We then employ this system in a communal storytelling environment as part of an interactive art installation and create a medium for collaborative creative expression.

Introduction

Humans are social beings, and one of the most astonishing consequences of our social tendencies is narrative intelligence - the evolutionary ability to organize experiences into narrative forms (Dautenhahn 2002; Mateas and Sengers 2003). This has had a profound impact on how humans have evolved and interacted with each other and their surroundings, from serving as a tool for situated understanding (Gerrig 1993) to mass cooperation via imagined realties (Harari 2014). This narrative ability is central to the cognitive processes employed in different experiences, from entertainment (e.g. books, television, movies, plays) to education (Dickey 2006; McQuiggan et al. 2008). It follows that developing computational systems that possess narrative intelligence may pave the way for machines that are able to interact with human users more naturally because these systems understand collaborative contexts as emerging narrative and are able to express themselves by telling stories. A number of narrative intelligence tasks have been studied from a computational perspective including story understanding (Miikkulainen 2000; Rapaport et al. 1989), story generation (Meehan 1977), commonsense reasoning (Liu and Singh 2004), and interactive narrative (Riedl and Bulitko 2012).

Aspects of narrative intelligence that are less explored from the computational perspective include the communal/social nature of storytelling and visual representations of narratives. We are interested in furthering these two areas of narrative research, and in particular exploring how we can create technology that is able to participate in communal storytelling experiences. In creating *The Shape of Story*, we chose the symbolic visualization of narrative as a mode of participation because alternative representations of ideas offer alternative ways of thinking about those ideas (Panjwani 2017; Minsky 2007). Thus, a computer agent that is able to generate alternative representations of a narrative may be able to offer valuable and thought-provoking contributions to a communal storytelling environment. Artistic visual representations of narratives also lend well to computation, as they allow for abstraction and interpretation, thus minimizing the need for extensive knowledge-engineering.

Drawing on these principles, we created *The Shape of Story*, an interactive story circle experience in which participants collectively create a story line-by-line. Artificial intelligence in narrative understanding is used in conjunction with a symbolic visual language in order to visualize this story in real-time. The result is a narrative art piece that is collaboratively created by both participants and the computer.

Related Work

Our work is situated in the context of previous work that investigates the role of technology in communal storytelling experiences as well as work in visual art generation, narrative understanding, and experience design. This section will explore related prior work in each of these areas.

Communal Storytelling

Communal storytelling experiences are pervasive throughout our society, in settings ranging from campfire stories to pretend play to therapeutic storytelling in group meetings. Prior work has begun to explore how technology can contribute to social storytelling. The Tangible Viewpoints project investigates how multiple people navigate an existing narrative using tangible computational media. Other projects, like StoryMat (Ryokai and Cassell 1999), StoryBeads (Reitsma, Smith, and Van Den Hoven 2013), and Story-Making (Panjwani 2017) investigate how technology can aid in story recording and knowledge transfer amongst individuals and within communities.

Most relevantly, a prototype Wizard-of-Oz project called Show and Tell implements a social story-building environment for children in which a computer can participate and contribute verbally to a communal story (Glos and Umaschi 1997). Similarly, PartyQuirks incorporates virtual agents that participate in social story-building via theatrical improvisation (Magerko, DeLeon, and Dohogne 2011). Both of these projects explore how a computer can participate as an equal in a storytelling experience, rather than serving as a tool for the playback, recording, and sharing of stories. We are interested in expanding upon this area of research by investigating how a computer agent might contribute to a social storytelling experience via a different modality of expression: visual representation.

Visual Representation

The connection between visual representations and computation has its roots in art generation. A significant amount of work has investigated how to create computer-generated visual art, with projects ranging from abstract art generation (de Silva Garza and Lores 2004; Guzdial et al. 2017) to the generation of more realistic art (McCorduck 1991; Norton, Heath, and Ventura 2013; Colton 2011) to collaborative art-making experiences involving both human and computer participants (Davis et al. 2016).

Our work is particularly rooted in abstract and symbolic visual art generation. This was a deliberate choice - by representing narratives in an abstract symbolic manner, we avoided issues of extensive knowledge engineering and allowed for thought-provoking individual interpretations of the art piece. In order to represent narratives in this way, we created a visual language which draws on inspiration from abstract geometric art in the style of Kandinsky, symbolic narrative-based art in the style of Joan Miró and the more recently created Blissymbols (Bliss 1965). These sources of inspiration influenced the individual elements of the narration, such as the subjects and the verbs. Symbolic languages like Egyptian and Mayan hieroglyphics similarly influenced how we illustrate the continuity and narrative features of the spoken story inputs.

Prior work has investigated how to generate artwork of similar abstract/symbolic styles (Xiong and Zhang 2016; Zhang and Yu 2016; Hall and Song 2013). However, all of these systems focus on the visual aesthetic of the images without an eye for the symbolism and narrative meaning of the artwork. In the literature, narrative-based art generation is manifested primarily in the form of comic strip generation systems (Shamir, Rubinstein, and Levinboim 2006; Thawonmas and Shuda 2008; Alves et al. 2008). Shamir et al. draw on the expertise of comic artists (McCloud 1993) in order to develop a framework for computationally generating comic strips from game logs. The authors stress the importance of symbolism and abstraction in comic art, stating that "[u]sing abstract icons instead of realistic images focuses our attention through simplification, eliminates superfluous features, and creates higher identification and involvement" (Shamir, Rubinstein, and Levinboim 2006). In addition, they outline several different methods for translating time (in the narrative) into space (in the comic). These include breaking time transitions down in moment-to-moment, action-to-action, subject-to-subject, and scene-to-scene sequences (Shamir, Rubinstein, and Levinboim 2006). Both Shamir et al.'s use of abstraction and their time-to-space transition types were influential in our system design.

There are also several systems that focus on generating visual symbols from natural language. Most relevantly, Wicke developed a system that is capable of translating verbal narratives into emoji symbols (Wicke 2017). This is similar to our work in that narratives are told pictorially, not phonetically, but it differs somewhat in that our system strives for a highly abstract artistic representation, more similar to the primitive style of cave paintings than modern emojis. In addition, Cunha et al. present a position paper indicating interest in developing a system that generates icon-like symbols that represent concepts in order to help designers with creative ideation (Cunha et al. 2015). In this paper, they point out several key difficulties with symbolically representing natural language, including the need for extensive domain-specific knowledge (Cunha et al. 2015).

Narrative Representation

The field of narrative representation is also relevant to this project. In order to distill a text-based narrative into visual art, the story must be represented in a form that the computer can understand and use to generate images. Fillmore originally presented *case frames* as a way of representing a story so that a computer can understand it (Fillmore 1967). These are data structures that contain all of the information about a particular verb, including the agent performing the verb, the experiencer, the object, instrument, goal, time, and location (Fillmore 1967). Stories can be distilled into a series of these *case frames*.

Oshita uses Fillmore's work with *case frames* to build a system that can generate animations given natural-language commands (Oshita 2009). The frames used in this system are customized so that they can more accurately represent animations. Fields in these *motion frames* include item, agent, motion, instrument, target, contact position, initial posture, and adverbs (Oshita 2009)

In our case, both the artistic styles that we were inspired by and the importance of symbolism in comic strips implies that literal frame representations of each verb are not necessary. Previous work has been done in moving from specific information extracted from natural language to more general and abstract representations. Schank's research in cognitive science posits that all verbs in the English language can be mapped to a small set of fourteen primitive actions (Schank 1973). This allows complex narratives to be represented using a very small number of frame types. Similarly, Talmy's work in linguistics and cognitive science suggests a way of representing complex linguistic concepts in terms of force dynamics, abstracting away unnecessary detail and distilling an action into basic components such as an agonist, an antagonist, a tendency towards movement/rest, a resultant action (motion or rest), and the relative forces between the agonist and antagonist (Talmy 1988).

Experience Design

The Shape of Story is not just a technical system, but a co-creative experience. The design of this experience draws on related work in creating engaging interactive art installations

Figure 1: Storytelling experience in *The Shape of Story*

(Edmonds, Muller, and Connell 2006; Wouters et al. 2016) and facilitating intimate experiences in public art (Loke and Khut 2014). Specifically, we drew on two different models of creative engagement in order to motivate the experience design for *The Shape of Story*.

The first, presented by Edmonds and Muller, stipulates the importance of *attractors*, *sustainers*, and *relaters* in creating engaging interactive art installations (Edmonds, Muller, and Connell 2006). Attractors are aspects of an installation that initially draw participants' attention, sustainers are aspects of the installation that encourage the participant to continue interacting, and relaters are aspects of an installation that encourage participants to return in the future (Edmonds, Muller, and Connell 2006).

In addition, the communal storytelling experience that we were striving for in *The Shape of Story* necessitated a comfortable and intimate environment. For this, we drew on Loke et al.'s work on creating intimate aesthetic experiences in public spaces (Loke and Khut 2014). Loke et al. propose a four-stage model. In the first stage, *welcoming*, participants are invited by a facilitator to join in the artistic interaction. In the second stage, *fitting and induction*, participants are given a practical introduction to the technology they will be interacting with. The third stage, *the ride*, consists of the main experience of the installation. Finally, participants are able to participate in *debriefing and documentation* of their experience in order to facilitate closure and reflection. All four of these stages are led by a facilitator and incorporate ritualistic elements. This increased focus on actively facilitating transitions into and out of interaction with an art piece is suitable for artistic experiences that require a greater degree of intimacy and privacy.

Experience and Physical Installation

This section will go into further detail about how we utilized prior work in experience design in order to build a novel co-creative storytelling environment. *The Shape of Story* installation was recently presented to the public at a May 2017 exhibition at the Eyedrum Art and Music Gallery in Atlanta, GA. This section describes the version of the installation presented at this exhibit.

Participants who approached *The Shape of Story* exhibit entered a hallway filled with paintings of famous stories rendered by our system. This exhibition served as an initial *attractor*, and as participants gained interest, they were *welcomed* to join in the interaction by a facilitator. The facilitator invited 5-6 participants to remove their shoes and enter the story circle, a circular room walled off from the rest of the exhibition space by soft gray flannel curtains. The act of removing shoes and entering into this closed-off room was intended to serve as a *threshold moment*, or a moment specifically designed to initiate the participant into a "special or ritual space" (Loke and Khut 2014).

Participants were then invited to sit on pillows surrounding a circular projection surface (see Figure 1). The facilitator joined the circle and explained that the experience would involve collectively building an oral story together, beginning with a prompt supplied by the facilitator and continued line-by-line around the circle of participants. This was the *fitting and induction* phase.

The prompts that we selected for this particular installation were intended to be both open-ended and easily expanded upon, in order to lead to the generation of a variety of different stories while also reducing intimidation. The prompts were intended to elicit make-believe stories rather than personal accounts, as we felt that asking participants to share personal stories with each other might make them unnecessarily uncomfortable. Some example prompts included: "He woke to the smell of smoke", "He never believed in treasure hunts even as a kid until his 25th birthday", and "He was sure his heavy breathing was going to give him away".

After the induction, *the ride* begins. Each participant speaks into a special glowing speaking device (with a wireless microphone embedded inside), and after each line, the computer "artist" contributes to the dialogue by drawing its artistic interpretation of the line that it has heard onto the projection surface in the center of the circle. Every element of the visualization including the shapes, symbols, color, animation speed, and line thickness is symbolically related to the words that were spoken (see *Technical Implementation* for details). The story begins in the center of the circle and spirals outward; a completed short story can be viewed in Figure 2.

The completed visualization is in itself a *documentation* of the experience, serving as an artistic relic of the otherwise ephemeral story that was told. Previously told stories are projected through a window overlooking the rest of the exhibition space as an additional method of documentation. This also serves a dual purpose as an *attractor*, encouraging passersby to approach the exhibit.

At the end of the interaction, participants are encouraged

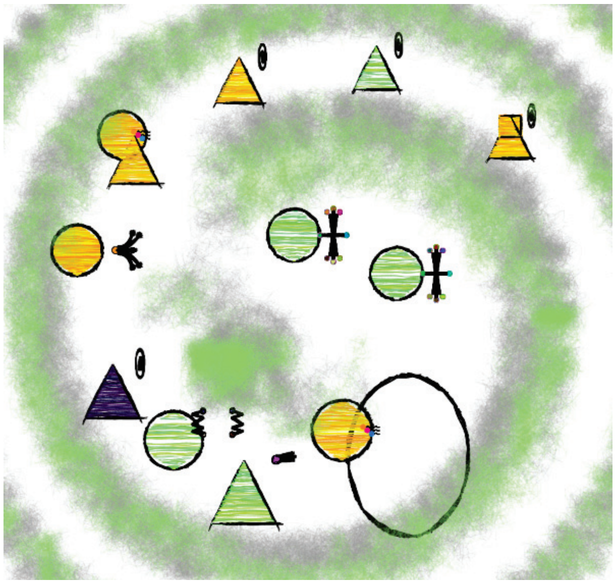

Figure 2: Story visualization in *The Shape of Story.* The partial story that generated this visualization was (slashes indicate a new speaker): The pool of glowing water did not seem safe, but she felt drawn to it. / She walked to the lake / and climbed into it. / Suddenly, she heard a noise. / It was coming from below. / She called out to her friend John. / Together, she and John dove deep into the water / There, they found a treasure chest. / They opened it / and inside of the chest, they found lots of gold.

to *debrief* and reflect upon their experience by asking questions about the visualization, examining the projected installation, and returning to the hallway outside to review the paintings with their experience in mind. The hope is that this documentation and debriefing will function as a *relater*, encouraging participants to think more deeply about their experience and possibly return in the future.

Care was taken in the design of this experience to facilitate a comfortable and intimate storytelling environment. Building stories together and sharing personal thoughts can be intimidating, and the private environment, ritual elements, soft lighting, and comfortable seating were all designed to minimize the fear of social embarrassment (one of the main factors that discourages participants from interacting with public art installations (Brignull and Rogers 2003)).

Technical Implementation

Creating a system that is capable of understanding a narrative and representing it in a symbolic artistic visualization engenders several key technical challenges including issues related to narrative understanding, representation, and abstraction. This section will go into detail about the technical implementation of our system and how we developed solutions for each of these issues.

External Tools

In the implementation of our system, we utilized several existing natural language processing tools, including StanfordCoreNLP (Manning et al. 2014), an open-source NLP toolkit, and a Word2Vec model (Mikolov et al. 2013) trained on Google News (Miháltz 2016), which takes text as an input and outputs a vector space that groups words together based on their similarity. For the visual representation, we used p5.js (McCarthy 2015) and p5.scribble.js (Wullschleger 2016), two open source JavaScript libraries, as foundations to build our own visualization engine.

Overview

In order to establish a common data structure that could not only represent text but also be translated into artistic visualizations, we drew on previous work in narrative representation (Oshita 2009; Fillmore 1967). Consequently, a story in our system is made up of a series of frames. Each frame in the story contains an *action*, an *emotion*, a *setting*, a *sentiment*, *subjects*, and *predicates*. In the current implementation, we chose to use an "action-to-action" transition scheme (the most common transition scheme used in comics) (Shamir, Rubinstein, and Levinboim 2006), meaning that each frame corresponds to one verb in the story. This typically corresponds to one sentence per frame, but compound sentences or sentences with lists of verbs can generate multiple frames.

After using the p5.speech library (DuBois 2015) to convert the line of dialogue to text, StanfordCoreNLP is used to extract relevant information from the story, including sentiment, prepositions, verbs, entities, and dependency relationships between different words in a sentence. This information is then processed into frames using our logic in combination with Word2Vec, and sent to the visualization engine. The visualization engine then takes these frames and converts each frame into a visual panel (like a comic panel). The information stored in every frame is mapped to a visual representation. To compose a panel, the visualization engine determines the spatial relations between the entities present in that panel based on the *setting* information, and the *action*. Based on this information, the panel area is then divided into bounding boxes that confine the drawing area of every element in that panel.

To draw the story from the panels (in the form of a comic-like strip), it is essential to maintain a linear chronological relationship between the panels. As a result, the engine renders the contour of the strip that will contain the panels at the start of the visual process. The contour is a spiral (inspired by circular Mayan narrative art pieces). As each panel is processed, it is placed in the spiral contour with the first panel drawn at the center of the spiral and subsequent panels drawn outwards from the center, one after the other.

The overall spiral comic structure as well as the individual panel elements are animated and are generated as a function of time to give the illusion of an art-piece that is being painted in real-time and to make the aesthetic experience more engaging. This whole process happens in real-time; that is, the moment a sentence is uttered, it is processed and

Verb	Basic Action
drive	move
buy	ingest
yell	speak
consider	think

Table 1: Example mappings from English verbs to the basic actions used by our system

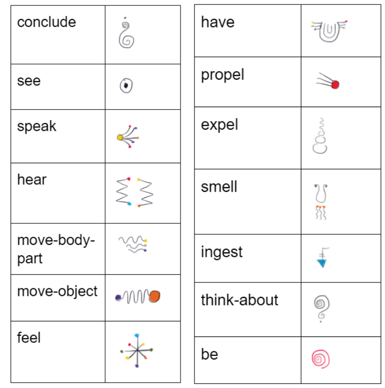

Figure 3: Action visualization

visualized. This allows participants to receive immediate visual feedback on how their contribution was interpreted and how it affected the overall story. The following sections will go into further detail about the implementation of the components of each frame.

Actions

Natural Language In order to avoid the need to equip the system with an extensive library of hand-authored visual symbols, we chose to create visual representations for 14 basic actions (see Figure 3). We then mapped each English verb that was read in by the system to one of these basic actions. This mapping was achieved using the Word2Vec model. For each of the 14 basic actions, the vector distance between that action and the English verb under consideration was calculated. Then, the action with the shortest vector distance (i.e. the most similarity) to the English verb was selected. Some example verb mappings are shown in Table 1.

This approach was inspired both by Schank's research on primitive actions and Talmy's research on force dynamics (Schank 1973; Talmy 1988). We drew directly from Schank's work in initially compiling a list of basic actions, but we modified the list slightly for two reasons: 1) to work more effectively with the Word2Vec model (this required changing two-word actions like "move-object" to single word actions like "move") and 2) to ensure that all sentences mapped to a reasonable action (this required adding the actions "have" and "be"). The action list we ultimately used is as follows: smell, move, think, ingest, speak, see, hear, feel, have, conclude, be, transport, expel, propel.

Visual Representation The visualization of the 14 actions consists of two aspects - the representation itself and the computational generation of the final output. The representations were inspired by studying the paintings of Joan Miró and Egyptian hieroglyphics. These representations are stored as mathematical functions of time, consisting of a combination of interpolations and different mathematical curves (Bezier, Neville, sin, cos, etc.). When a spoken verb maps to one of the 14 verbs, the corresponding function generates a time dependent representation on the screen (see Figure 3).

Subjects

Natural Language The list of subjects for each frame contains a list of the entities that are performing the verb (e.g. in the sentence "My dog and I took a walk", both "dog" and "I" are subjects). StanfordCoreNLP's dependency resolution (Chen and Manning 2014) and co-reference resolution tools are used to extract this information from a sentence (Raghunathan et al. 2010). A subject can be either an *object* or an *agent*. Objects are non-living things (e.g. chair, box). Agents are living things and can be either *human* or *non-human* as well as *male*, *female*, or *neutral*. A Word2Vec model similar to that used for actions is used to classify agents along these parameters (see *Actions)*. For example, the subject "princess" would be classified as a human, female agent because the word vector for princess is more similar to "human" than "animal" or "object" and more similar to "female" than "male".

Visual Representation The entities defined above (objects and agents) have shape representations, a choice that was strongly influenced by psychology research in abstract narrative visualizations (Heider and Simmel 1944) (see Figure 4). An object is represented by a square, a non-human agent is a rectangle, a male human agent is a triangle, and a female human agent is a circle. These shape choices were influenced partly by general artistic trends and partly by personal preference. For example, curves and circles have long been used to represent femininity in art, and similarly the straight angles of the upwards pointing triangle evoke masculine symbolism. We chose to represent objects using squares, which to us evoked the idea of a box or block being manipulated by the larger triangle/circle agents. To render these images on the canvas, our system stores them as mathematical functions of time. Whenever a story element maps to these entities, the visualization engine calls the corresponding function to draw animated lines that define these shapes. As a result, the participants see these shapes realized in real time. All shape forms are drawn as black sketchy lines to give them the illusion of being hand-drawn.

Sentiment

Natural Language A sentiment is extracted for each sentence using StanfordCoreNLP's sentiment analysis (Socher et al. 2013). The sentiment is represented as an integer value ranging from -2 to 2, with -2 corresponding to a very negative sentiment and 2 corresponding to a very positive sen-

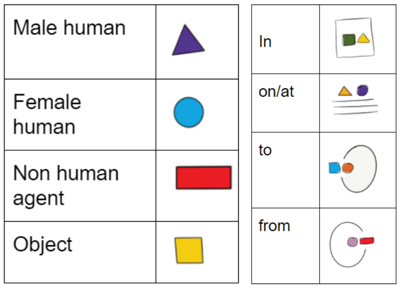

Figure 4: Subject and Setting visualizations

Color	Sentiment	Sentiment Value
grey-black	very negative	-2
purple-blue	negative	-1
green	neutral	0
yellow-orange	positive	1
pink	very positive	2

Table 2: Color to sentiment mappings used by our system

timent. The cumulative sentiment value for the entire story is the average of the sentiment values for each frame in the story.

Visual Representation The sentiment values calculated above map to a color value that plays a two-fold role in the visualization. On a frame level, the color is used to the fill interiors of the object and agent shapes. On the story level, the color is used to draw the spiral comic strip made of Perlin noise (Perlin 2002) and is representative of the overall story sentiment at the point that this function is called (see Figure 2). In the current iteration, the story level sentiment function has to be called by a human user (a facilitator triggered this function each time the speaking device was passed to a new person). The decisions for the colors used to represent the sentiments were inspired by prior research on color psychology and color theory (Cao 2015). For example, the color gray evokes feelings of gloom, and therefore we used it to represent negative sentiment. Similarly, yellow is generally symbolic of positive energy and happiness and was therefore used to symbolize positive sentiment. The colors we chose and their associated sentiments are presented in Table 2.

Emotions

Natural Language An emotion was also extracted from sentences that contained the relevant information. StanfordCoreNLP's part-of-speech tagger was used to extract adjectives from a sentence (Toutanova et al. 2003). These adjectives were then mapped to emotions using a Word2Vec model method similar to that used for actions (see *Actions*). We used Ekman's six basic emotions (disgust, fear, happiness, sadness, surprise, and anger) for the mappings (Ekman 1992).

Visual Representation If and when emotion information was stored in a frame, it was mapped to the line quality used to fill the interior of the object and agent shapes. Line quality has two parameters - thickness and speed of the drawing animation. For example, if the detected emotion was anger, a fast-thick line would fill the interior, a sad emotion would trigger a slow-thick line, and a happy emotion would create a fast-thin line.

Settings

Natural Language Rather than representing specific locations with individual symbols, a task which would require an extensive hand-authored library of visuals, we chose to represent settings by the agent's relationship to them. As a result, directional prepositions like *in*, *on*, *to*, *from*, and *at* were used to generate visuals representing settings. StanfordCoreNLP's part-of-speech tagger (Toutanova et al. 2003) was used to identify these prepositions in a sentence. This approach was inspired by the use of abstract symbolism in comics (Shamir, Rubinstein, and Levinboim 2006; McCloud 1993) as well as by psychological findings that show that even very abstract animations (in which locations are implied using basic shapes like boxes) can evoke complex narratives when presented to human subjects (Heider and Simmel 1944).

Visual Representation The five prepositions (*in*, *on*, *to*, *from*, and *at*), were stored as time-animated functions that could be called by the visualization engine based on the frames generated from the sentences (see Figure 4). *From* is represented as an ellipse with an orifice on its top right where the agents are drawn to indicate that they are leaving. Similarly, *to* is represented by an ellipse with an opening on its left to indicate that the agent is coming. *On* and *at* are drawn as three horizontal lines on top of which entities are placed, and *in* is a rectangular box inside which everything else is drawn.

Feedback and Future Work

We did not conduct a formal evaluation of the installation but we did make some informal observations while it was installed at the Eyedrum gallery in Atlanta. These observations have informed our goals for future work. Most participants engaged in a single 5-10 minute storytelling session, but some stayed for a second or third session. Based on the informal feedback that we received, participants seemed to enjoy the communal interaction and physical installation, which played an important role in helping participants to feel comfortable with the story-sharing experience. In the future, we aim to build upon the installation and experience design. This would include allowing the participants to rotate the circle and look at the generated art from different angles, allowing participants to touch and alter the visual elements, and providing some form of artifact for participants to take home as documentation of the experience.

We also received some feedback about the technology. Animating the drawings made them come to life and helped participants attribute agency to the computer, but we concluded that the technology needs to be improved to better handle rapid input so that participants always receive immediate visual responses to their statements. Any delay breaks the connection between spoken word and visual symbol and can lead to confusion. In future work, we aim to reduce this response time as well as reinforce the symbolism by visualizing more complex story elements (e.g. representing human relationships) and attributing animations to verb actions such that the animation conveys the meaning of the action.

After the experience, most participants wanted an explanation of what the symbols in the visualizations meant. In future work, we hope to facilitate deeper engagement by allowing participants to alter or replay previously visualized frames via speech or touch.

Finally, we would like to conduct a formal evaluation of our system. This evaluation could measure and assess the accuracy of story representation, engagement of the interactive experience, aesthetics of the visualization, and degree of participant understanding and interpretation.

Conclusion

We have developed an interactive art installation in which humans and a computer agent can engage in real-time creative dialogue with each other by collaboratively creating a narrative-based art piece. As human participants collectively build a story together, our system is able to generate an artistic representation of this story using its understanding of the narrative in combination with a symbolic visual language that we have created. We have contributed a system for narrative understanding and visualization as well as an experience design that facilitates co-creative, multi-modal dialogue between humans and computers.

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