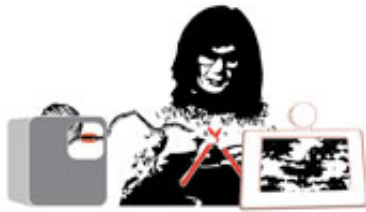# Spyn: Weaving Stories into Handcrafted Artifacts

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ABSTRACT

Spyn is a system for knitters to record, recall, and share information surrounding the process of handcraft. Using the yarn as a timeline of a knit's creation, Spyn allows knitters to associate digital annotations to knit yarn. The current prototype uses patterns of infrared ink printed on yarn in combination with computer vision techniques to associate locations in knit fabric with audio and visual messages recorded by the knitters during the knitting process. When users photograph the knit yarn using Spyn, the system analyzes the ink patterns on the yarn and visualizes events over the photograph of the knit. Over time, knitters weave a one-dimensional thread of yarn into a three-dimensional fabric of personal stories. In this paper I present a qualitative study of knitting practice and the iterative design of Spyn.

INTRODUCTION

Unlike machine-made objects, handcrafted objects often take significant time and skill to create. A handcrafted artifact can physically embody the skill and time involved in its production. For example, the subtle unevenness of stitches in a hand-knit textile may be an indication of the rhythm and tension of the knitter at the point in time the stitches were created. Moreover, handwork can be directly coupled with semantics such as representations of land, social organizations, and ideological systems (Heckman 2003). The knot work of the Inka Khipu, for instance, was used to encode different types of numerical and narrative data (Quilter and Urton, 2002). Handcrafted objects are "charged" with the history, narratives, and memories of the people who created them, as well as the people with whom they interact (Costin 1995; Ferber 2005; Macdonald 1988). Yet a handmade object itself cannot tell those personal stories of its making, and only hints at the human energy poured into its creation.

Through the design of Spyn, I seek to augment the experience around a knitter's creative process. Many digital creative tools focus on optimizing productivity, and emphasizing the final product over the process of making. The current consumer version of Adobe Photoshop, Photoshop Elements 6.0, for instance, allows users to interact with Photoshop features with reduced control and functionality. Although such tools may aid one's adoption of new creative technologies, they offer little to support the social aspects of an individual's creation process. This effort attempts to enhance social processes inherent in the craftwork by connecting knitters with their handmade creations.

Spyn is a system that lets knitters connect the physical handcrafted object with the intangible personal experience they have with its creation. Spyn captures information while a person knits and allows for the subsequent retrieval of the information using the knit artifact. Spyn uses computer vision techniques in combination with patterns of infrared ink printed on yarn to correlate locations in knit fabric with events recorded during the knitting process. Knitters keep track of their creation processes by implicitly and explicitly capturing information while knitting. By recording such information and mapping each record to locations on the physical handcrafted artifact, the crafter can control the codification of

Figure 1. Spyn enables the automatic and manual capture of information while knitting. A rotary encoder (left) keeps track of the amount of yarn pulled from its source. The mobile device stores this yardage and maps it to sensor data, such as GPS coordinates, temporal data, and media (photos, audio and video files) captured throughout the process of craft.

meaning within the physical textile and capture messages relating to the knitter's techniques and memories. Preliminary evaluation of a first prototype suggests Spyn has the potential to preserve the crafting process while enabling new avenues for creative expression.

In the remainder of this paper, I will discuss motivations, existing related work, and fieldwork with knitters that inspired the design of Spyn. Then, I will present my design considerations, iterative design process for Spyn, and present conclusions based on this research.
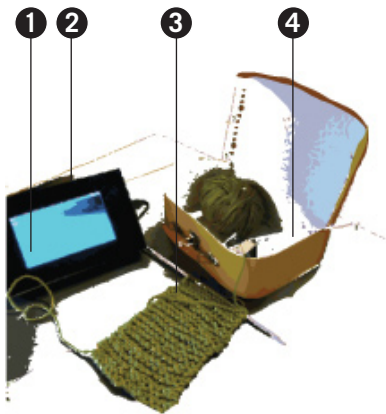
CRAFT AND TECHNOLOGY

Seeped in cultural tradition, the process of handcraft is often considered opposed to automation and advancements in modern technology. Such a view of craft predicts an odd pairing with tools for ubiquitous computing. Yet this seemingly contentious relationship may overlook computing techniques that support existing cultural and religious practices through automation, such as in orthodox Jewish homes (Woodruff, 2007). Devices designed to support historical social and cultural practices have the potential to both motivate the preservation of rich heritage as well as offer new opportunities for exploration. Without affecting the appearance or texture of the crafted artifact, I seek to leverage meaningful processes inherent in handcraft while maintaining its creative end. In the design of Spyn, I investigate the use of hand-knit techniques to open new avenues for creative expression.

Such integration of technology and handcraft is also evidenced by recent art exhibitions that combine traditional handwork with new traditions in technology. Open Source Embroidery: Craft and Code at HTTP Gallery[1], explicitly explores connections between the collaborative characteristics of needlework, craft and Open Source technology. A knit dress I recently co-created for the Awareables exhibition of 'conscious clothing'[2] similarly explores the connection between knitting and storytelling; the dress, made of magnetic tape, is being played back and recorded by the knitter wearing the dress (Rosner and Ryokai, 2008).

KNITTING

Like many domestic crafts, knitting was originally a process that employs hand-eye coordination for the production of useful goods. In reaction to an increase in mass production during the late 19th and early 20th centuries, William Morris and his followers (Lucie-Smith, 1981) helped to reinstate craft as a valued practice, a phenomenon referred to as the Arts and Crafts Movement. More recently, craftwork and knitting has been used for vastly different purposes (Piercy, 2004), from political protest during the Vietnam War, to helping restore national identity for the Inuit, who have used craftwork to build new institutions in Canada (Graburn, 2004). In such cases, the knit craft transformed from a largely utilitarian trade to an activity associated with recreation, peaceful protest, and identity.

Figure 2. *Components of Spyn:* 1) Mobile computing device with display screen with sensors for automatic data collection (GPS device) 2) standard web camera for video, image and sound capture and IR enabled camera for scanning device, 3) yarn printed with invisible IR ink, and 4) Phidget Rotary Encoder for encoding length of yarn.

1   An exhibition facilitated by Ele Carpenter: http://www.http.uk.net/.

2   http://www.sjquiltmuseum.org/exhibitions.html

I investigate knitting as an example of handcraft for several reasons:

1. Knitting recently surged in popularity in the United States (Craft and Hobby Association, 2008), resulting in an increase in the variety of knitters.[3] An increase in younger knitters also provides a broader platform from which to explore the design of technology to augment handcraft.

2. The knitter's objective can vary across space and time. Knitting is a portable and flexible craft that is motivated by a variety of reasons, including people, events, seasonal change, a need for relaxation, or multiple overlapping purposes (Fields, 2004). Knitters can be working on several projects concurrently, or finish one at a time. There is also a long tradition of knitting for charity: e.g., women in charity knitting groups knit socks, breeches, and shirts for soldiers during World War I (Johnson, 2005).

3. Knitting is an example of a handcraft in which a linear artifact is turned into a multi-dimensional textile. The transition from yarn into fabric possessing of width, breadth and texture enables the mapping of records to take place on a physical timeline; the spatial and the temporal dimensions of the knit process are thus intertwined.

A finished handwork project therefore serves as a physical manifestation of a knitter's effort, skill, and productive use of time (Prigoda, 2007). Yet it is not always obvious to the untrained eyes just how long it has taken for the knitter to produce such a work of art. In addition to the skills manifested in the physical article, the knit frequently travels with knitter across distance and time, charged with the knitter's experiences.

The goal of this project is to connect these two parts of the knit art: the visible (the artifact and physical attributes of the artifact) and the invisible (memory and social context).

Information Technology, Craft and Knitting

Several craft phenomena have emerged that use information technology to support knitting and crafting practices. Stitch'nBitch is one global movement in which women—sometimes referred to as "chicks with sticks"—gather around their craftwork, both digitally and physically, to knit, share techniques, and socialize. In physical locations such as local cafes, knitting stores, and other public spaces, craft groups explore a wealth of traditional crafts, such as embroidery, cross-stitch, and crochet. Some groups promote social welfare and support political causes, such as Afghans for Afghan[4]. On the Internet, knitters share techniques, resources and stories around their craftwork on private knitting blogs and public websites dedicated to the craft. Ravelry.com is a community driven website for knitters that allows participants to keep track of information about different yarns,

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3   The Hobby Industry Association (HIA) reported sales of needlecraft supplies increased from $7.4 billion in 2001 to $8.5 billion in 2002. Media Research, Inc (MRI) has claimed that the average knitter in 2002 was 55.7 years old while knitters three years before were 56.8 years old.

4   http://www.afghansforafghans.org/

tools and patterns as well as connect with fellow crafters. My work is inspired by this recent surge in online and off-line social activity surrounding knitting.

RELATED WORK

Handcraft, Technology, and Wearable Computing

Previous work to embody handcraft in the design of new technology has demonstrated the potential of fostering novel forms of creative expression (Ryokai et al., 2004) and children's storytelling (Ryokai et al., 1999). In addition, recent work on children's computational craft has highlighted uses of craft for learning, such as computational textiles that explore engagement in computer science education (Buechley et al., 2008). kameraflage (Dickie, 2008) is a display and print technology for garments, based on infrared light reflecting ink that is invisible to the human eye, but may be detectable by camera phones imagers. While the invisible ink technology used in kameraflage is related my implementation of Spyn, the goal of kameraflage is to hide "secret" pictographic expressions on cloths, and later reveal them on images taken by camera cellphones. The authors do not explore how the drawings with the IR reflecting ink are applied.

In the area of wearable computing, several projects have added displays or information technology to clothes. Yet, my system should be distinguished from these "Wearables," and should also not be confused with systems that are using, e.g., conductive fabrics, etc. Reactee is a service that allows people to design personalized T-Shirt prints that include a phone number that other people can text to, such as a print on a T-Shirt that reads: "Text GUITAR7 to 41411 to hear about my next gig." While a cell phone is used to dial the number printed visibly on the garment, the number is used as a pointer to information stored outside of the garment, not as a device to capture the process of handmade craft.

Finally, in Shaping Things, Bruce Sterling describes a future where everyday objects can be tracked in space and time (see Sterling 2005 for his discussion of "Spimes."). Spyn is related to Sterling's vision yet enables people to add unique and identifiable markers as a handcrafted object is being created, and correlate locations on the object with various personal events and messages.

Information Capture and Access

A number of efforts have emerged to build systems and devices that support the capture and access of media associated with life events. While some of these systems function autonomously, such as life-logging technologies (Berry, 2007) other systems are both manually and automatically controlled, (Abowd et al., 2000; Bell et al., 2007; Rekimoto, 1999) including systems that provide multimodal note-taking of personal and shared notes (Whittaker, 1994; Stifelman 2001; Klemmer, 2003) and actions associated with notes shared over the web (Truong, 1999). ButterflyNet (Yeh et al., 2006), a system for field biologists, correlates handwritten notes and photos to physical specimens using their "visual specimen tagging" technique. While my work is inspired by this work, Spyn addresses a

different design space: connecting areas on a handmade physical objects directly with messages recorded while it was created. Additional ubiquitous computing techniques have supported creation processes such as prototyping (Hartmann et al., 2006), demonstrating the value of devices to support reflective practices.

INTERVIEWS AND FIELDWORK

I conducted fieldwork with knitters in a variety of locations and contexts to better understand modern knitting practice. First, I participated in four knitting circles in the greater Bay Area from June, 2007 through August, 2007, meeting with each group for one to two hours on average twice a month. The knitting circles consisted of a unique blend of professional, non-professional, or retired knitters, mostly women, who varied across age and demographic. Two groups were composed of young, mostly female professionals including teachers, performers, and expecting mothers; a third group was comprised of intellectual, middle-aged professionals and retirees in their 40s to late 70s; a final group based in a local high-tech company during lunch breaks was composed of professional women in their late 20s to late 50s.

I spoke with over 30 knitters as I participated in knitting groups in order to observe knitters' latent needs and discover inspirations for design. Each group also met in a different type of location: a bar, a knitting shop, a public library and a company lobby. All groups varied in number of knitters in attendance, averaging about seven to ten knitters per session, though sometimes over twenty in the case of the professional group meeting in a bar.

In addition to observing the knitting circle attendees, I conducted semi-structured interviews with 13 knitters, investigating their crafting habits and motivations. I also had informal conversations with many knitters in person, visited several knitting stores, and spoke with knitters outside of organized group practice. Although I did not belong to knitting circles prior to this research, my own prior knitting experience often inspired impromptu encounters and informal discussions.

During my discussions with knitters, I observed that knitters enjoy not only the product of their activity, but also the process of knitting itself. Eight central themes arose based on this fieldwork:

1. PORTABILITY: Most knitters consider their craft portable, and view its portability as supporting their active adoption of the craft. Knitters knit in diverse locations, such as on the beach, on the train to work, in cafes during 'down time,' or in knitting circles. Some knitters described choosing to bring lightweight projects with them, such as socks, scarves and hats, and leaving heavy projects at home, such as a large men's sweater made of denim. I also observed that while traveling, knitters often carried a bag or basket for their project.

2. INVESTMENT: Knitters' projects varied from small pieces involving just a few hours to large pieces such as sweaters and blankets that take place over several

months or even years. Many knitters reported having several knit projects ongoing in parallel, tucking away half-finished knit projects in closets in the hope of future completion. Additionally, knitters often spend considerable money on projects, buying expensive yarns and needles and attending knitting classes. Even those who began to knit as a student on a tight budget, often ended up spending significantly more on knitted gifts than bought gifts.

3. ATTENTION: Knitters devoted different levels of attention to their knitting depending on the complexity of their pattern and the social activity surrounding their handwork. Knitting could be the focus of a knitter's attention or a rote activity, enabling one to 'multi-task' (e.g., listen to an audio book, attend a class lecture, or watch a television show). This shifting of attention is also present during conversation (as one knitter described, "I remember when I was chit chatting with another gal in the [knitting] group and she was like, 'excuse me, I'm at a difficult point… I'm going to be quite and concentrate for a few minutes and I'll join the group later.'")

4. REFLECTION: Knitters spoke of being motivated by seasonal change, moods and events. Such transient occurrences invited knitters to look forward in reference to past events (e.g., the cold winter weather inspiring a knitter to create a warm winter hat), as well as anticipate future recollection, (e.g., a knitter knitting a new born niece's shawl to commemorate the occasion.) Thus, the knitters' experiences while knitting evoked emotional and physical reflection (Stoller, 1995).

5. RELAXATION: Knitters often spoke of the benefits of using the repetitive rhythm of needles in their hands for perceived productivity (e.g. counteracting job-related stress.) Some knitters reported therapeutic aspects involving their physical interaction with soft and comforting materials. Other knitters discussed meditative effects of 'keeping their hands busy and minds free.' One knitter described finally convincing her best friend to learn to knit after her friend's doctor prescribed the activity.

6. ANNOTATION: Knitters often wrote handwritten notes on paper and attached them to complicated projects in order to keep track of their work for the future. Such notes enabled knitters to flexibly pick up and put down projects, fitting their knit work into the amount of time they had available (e.g., knitting while waiting for a bus.) Some knitters digitally annotate completed or ongoing projects using websites such as ravelry.com, Flickr.com, and personal blogs. They snap photos of their completed or ongoing projects, post the image to a website and overlay written annotations on the image. Such notes vary in length and purpose but generally fall into one or more of three categories: notes documenting craftwork (e.g., "alternating knit and purl stitches"), notes referencing the context surrounding the knitting (e.g., "crooked tying off row done in a big hurry, b/c the booth was closing. I did help them clean up, too"), and notes commenting on the photograph itself (e.g., "needs spa day!" in reference to the un-manicured hands holding a knit.)[5] These recorded musings, in the form of textual annotations, are

5.   flickr.com user Mercado
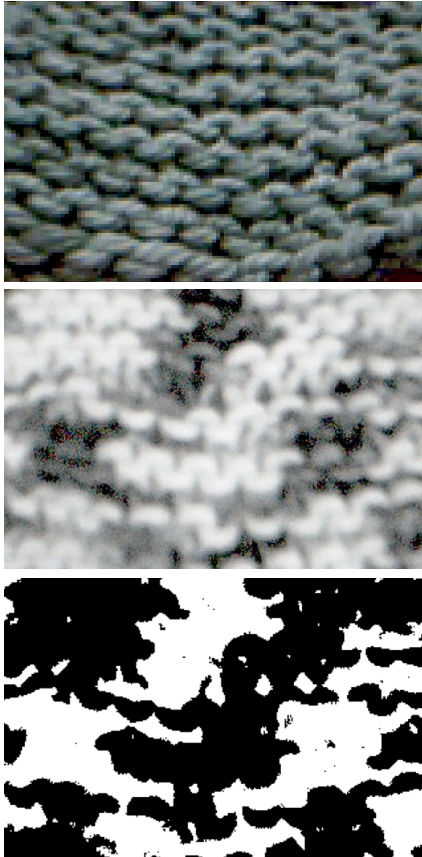
Figure 3. One garment shown in three views used in Spyn. (From top to bottom) The IR ink is invisible to human eyes. Invisible infrared ink is captured by our IR enabled camera. Processed image.

often a direct reaction to the image capturing while crafting.

7. PRODUCTIVITY: Knitters often described 'feeling productive' as they knit, creating physical, functional artifacts for themselves or others. When I asked a knitter who works as a software engineer why she started knitting, she explained, "It occurred to me last year that I had no actual useful skills." Knitters typically described giving their work to others, yet such gifting was motivated by different reasons, from a desire for appreciation, to plans of encouraging the completion of projects (as one knitter explained, "unfinished projects are usually for me").

8. PERSONAL AND SOCIAL: Knitting activities happened both in personal space, such as on the couch at home, and in social space, such as outdoors with friends or in knitting circles. When knitters meet with their fellow knitters, narratives were abundant. Storytelling evolved both around the process and the product. Knitters shared techniques and tools of trade, gossip and personal narratives inspired by the knitting projects. Several knitters also used online knitting blogs and forums to share their work, keep track of information about different yarns, tools and patterns as well as connect with fellow crafters.

Design Considerations
Motivated by insights from my fieldwork, I came up with the following considerations for the design of Spyn:

1. Capture
CAPTURE WHEN
Research Insight: The knitting process generally occurs on different days and at different times. Knitters take breaks for days, months or even years before picking up a project.
CAPTURE WHERE
Research Insight: The location knitting takes place in influences knitters' experience of their craft.
CAPTURE MESSAGES
Research Insight: Knitters collect and share myriad stories surrouding their craftwork both in knitting circles and on online knitting blogs and community webites.

2. Connect
CONNECT TO THE PROCESS
Research Insight: Knitters annnotate their physical knits with phyiscal notes, to mark their places, and digital tags and blog entries, to share stories and techniques.
MAKE THE PROCESS VISIBLE
Research Insight: Knitters actively used their knits to visually navigate their process. They often pointed out a missed stitch or evenly knit row by referencing an area in the physical artifact. Yet the physical knit artifact is disconnected from a knitter's experience of its creation after the knitting process.

Figure 4. (From top to bottom) Access information associated with physical knit (a) by touching points on captured an image of the knit (b) or touch the image to enlarge (c).

USE THE PHYSICAL ARTIFACT TO CONNECT

Research Insight: Knitted articles were often used as a point of reference during discussion and triggered topics of conversation with others.

3. Make Seamless

FIT THE INTERFACE TO THE ENVIRONMENT

Research Insight: Knitters often fit their technology into their environment. Some knitters explicitly turn their cell phones off while knitting to close certain communication channels. Technology often remained in the background of knitters' activity.

PRESERVE LOOK AND FEEL

Research Insight: The textures and colors of yarn as well as the choice of patterns and knitting needles were important parts of the knitters' process.

SPYN: AN INTERACTION SCENARIO

This section describes the design of Spyn, phrased in terms of a scenario in which Spyn is used over the course of a knitting project. Imagine a knitter sitting at a café begins to knit a hat she intends to give to her friend. As she casts-on her first stitches, she pulls yarn from her knitting basket. Her pull of the yarn triggers a small encoder in her basket (see Figure 1) to measure the length of yarn she pulled, and sends the information to her mobile device. In addition, her pull of the yarn causes a small printer on her basket to print a unique barcode invisibly with infrared ink onto the yarn. She touches a record button on her mobile device, and speaks aloud: "This one is for you. Happy birthday, Amy!" She stops the recording on her mobile device. The knitter continues to knit until she notices a mistake and begins to rip out her last three rows. Touching a record button on her mobile device, speaks aloud: "I want you to know, Amy, my purling isn't coming naturally today." She stops the recording on her mobile device.

Over the next month, the knitter continues her project, knitting at different times and in different locations; once at a café at night, a few times on the train to work, and often at home. During each knitting session, she pauses a few times to record a video message for her friend.

At the end of a month her hat is complete, just in time for Amy's birthday. As soon as Amy receives the hat, she photographs rim with her mobile device and pointers are mapped to different sections of the knit image on the display (see Figure 4). She touches the first pointer and a small image of her friend appears at a cafe accompanied by a date, time and location. She touches the image and watches a video of her friend at a cafe describing her unnatural purling. Amy is excited to watch where her friend was at the time the hat was started thrilled to receive such a unique gift. She ponders what she will use Spyn to create for her friend in return.

IMPLEMENTATION

Our prototype is comprised of a mobile computing device (Asus Ultra Mobile PC) with touch screen interface and built-in GPS, (see 1 in Figure 3). The device

is connected through USB to a Phidget encoder, a USB mechanical rotary device that encodes digital output (4) and standard and infrared enabled cameras (2).

Yarn and Resolution

We used infrared (IR) ink to locate positions on the yarn. 1 cm dots of ink are preprinted onto the yarn and the space between each dot increases linearly across the yarn. This pattern provides a maximum spatial resolution of the length of the yarn minus the varying amount of yarn occlusion, which changes based on the tightness and complexity of the knitting stitch.

Software and Vision System

The core system and user interface were written in Actionscript 3.0. The system uses SiRFDemo for logging GPS data and Logitech® QuickCam software for capturing images and video. The image processing software used to analyze each knit image was written in Java J2SE 1.6.0.

The image processing software maps the percentage of IR ink on the yarn to the percentage of yarn pulled from the rotary encoder. As a person knits, the system uses input from the rotary encoder to determine the amount of yarn pulled from the knitter's basket. Approximately 500 revolutions map to one yard of yarn pulled through the rotary encoder. When GPS data, digital images, or video is collected, the data is stored in association with the percentage of yarn pulled through the encoder. For every image of the knit used to access information, I produce a matrix with the same dimensions as the image (in pixels); each entry in the matrix is initially a 0. I apply a color threshold by adding a 1 to every matrix cell corresponding to an image pixel with an average intensity value of less than 150 (darker than medium gray). As a result, I produce a matrix of 0s and 1s corresponding to the area of the image in which the yarn was coated with infrared ink. I then average pixel values across both dimensions (rows and columns), calculating the gradient value of the differences between these pixel averages for both dimensions. I use the gradient value to determine the "knitting" direction in the image. Next I correlate the stored percentages of yarn pulled through the encoder (Y) with corresponding averaged matrix values. Finally, I map information associated with each Y value onto its correlated position in the original image of the knit.

Spyn Prototype

The Spyn prototype provided automatic capture of position data and enabled explicit authoring of image, video and audio data. The prototype automatically recorded GPS data and the amount of yarn used; it required no active use from participants beyond their existing knitting practice. When knitters manually captured image, video, or audio data, Spyn automatically associated such data with locations along a ball of yarn. To access the stored data, participants pointed the device at the knit garment (viewing a standard web camera image of the garment) and touched the screen. This triggered the prototype to overlay markers on the image where data was collected while knitting (by capturing and analyzing an infrared image of the garment). Participants could touch the markers to retrieve the information (image, audio or video data) associated with each marker.

FIELD TESTS AND USER REACTIONS

I report of the results of my field tests with eight knitters. While presented in a linear manner, my findings are the result of an iterative design process. The participants in these studies are not representative of a specific type of knitter in North America, but were chosen to represent a wide range of perspectives on the knitting craft.

Participants and Method

I conducted field tests with a total of eight knitters, visiting six knitters at their homes. Seven knitters lived in the San Francisco Bay Area and one knitter lived in Toronto, Canada. All but one knitter was female. Knitters varied in age from mid-twenties to early-eighties, and their vocations included retiree, elementary school teacher, graduate student, software engineer, and fabric store employee. I recruited knitters through online websites such as Ravelry.com, as well as through knitting stores, knitting circles, and previous contacts from my early interviews. All visits were videotaped or audio-recorded and most were transcribed in full.

I conducted field tests from August 2007 through May 2008. Each session lasted approximately three to five hours. Sessions typically consisted of three activities: one in which knitters retrieved messages already embedded in a scarf created with Spyn, one in which knitters practiced using Spyn to capture and retrieved a message of their own, and one in which knitters created something of their own with Spyn. Participants did not expect to use their knit material once they were done knitting (since they did not have access to Spyn after the session).

The following sections present distinct themes that arose from my field tests with knitters and my subsequent analyses of the recorded sessions.

Preservation and Memorialization

Participants who normally engaged in extensive craftwork (including needle-point, cross-stitch, cake-baking, cake-decorating, chocolate mold making, beading, jewelry work, and crochet) became increasingly interested in using Spyn to preserve conditions and thoughts surrounding their craft.

Esther, a retiree in her 80s, described how she wanted to "record the memory" and "purpose" of a project that was particularly important to both her and its recipient, a shawl for her granddaughter's wedding. Moved by the salience of her craftwork for this particular project, she demonstrated using Spyn to record the poignant, religious significance of her craft. She described capturing these notes in the hope that she could pass the "heritage" onto future generations.

Rather than record 'special' information, Penelope, a graduate student in her late 20s, deliberately recorded her individual ramblings. She spoke of "embedding a memoir" in her knit, capturing her craft-related thoughts while knitting. In one recording, she reflected on the effect of re-knitting a pattern:

[Begin recording] *Another thing that's really interesting is how simply doing it in a different yarn changes my context of that pattern. Or to be so close to the beginning of it, it makes me loose my frame of reference in that pattern. Like I have the pattern mentally for that type of yarn.* [End recording]
— Penelope

Penelope captured additonal audio recordings that she considered 'interesting.' sporadic musings:

[Begin recording] *The fact that I was so close to getting to the point where I could take a picture of it, I think, on some level, that type of subconscious excitement leads you to mess up…Or think you mess up… when you actually did not.* [End recording]
— Penelope

Such streams of consciousness where more commonly recorded by participants who habitually knit or crafted. Yet participants often recorded messages to preserve information with prospective importance or interest. The majority of media captured by participants were audio recordings in the form of comments and conversations. Participants often described scenarios in which they would want to take photographs but rarely took photographs during the knitting sessions. This may have been due to the participants' limited personal investment in the future of their knit garment based on the length of the field test. Participants' captured photographs included odd shots of a house cat, images of me, and documentation of their knitting progress. Explicit video capture was also less common but, when recorded, allowed knitters to embed additional context in their knits, such as spoken narration paired with moving image. In general, preservation was not overwhelmingly tied to particular types of media; rather it surfaced as a form of close documentation tied to participants' physical garments. In reference to the types of message passing enabled by Spyn, one participant described, "You're holding a physical object. It feels more permanent."

Values in Craftwork

Although most participants welcomed the chance to capture additional information surrounding their craftwork, some participants had reservations about combing technology and craft before using Spyn. Initially skeptical, Esther asserted that in order for it to be worth recording her explanations of her craftwork, the piece she was creating needed to be for a "particular, important occasion." When she associated the knit with a shawl for her granddaughter's marriage, one linked with religious and familial sentiments, she spoke of her messages as an "addition to the gratification of this project."

Karen, a graduate student in her early thirties, contemplated how younger generations in her family failed to appreciate the time and labor required to produce objects by hand. Reflecting on the knit she made with Spyn, she spoke of the difference in their upbringing from her own and their ignorance of the value of handcraft. Karen saw Spyn as a medium to channel personal values to her knit's recipients.

[My knit] is like emotional blackmail.
–Karen

In addition to valuing the process of handcraft, knitters also found aesthetic choices such as knitting pattern, yarn and needle important. After using Spyn, participants often spoke of valuing the ability to remain in control of such choices. One participant envisioned adding beads by hand to the places in which she had embedded messages in order to further augment her knitwear. Amy (a software engineer), participants were relatively uninterested in understanding details of Spyn's technical implementation or the yarn's invisible infrared patterns.

Metaphors

Participants associated a distinct set of metaphors to the handwork they created with Spyn, often comparing their work to blogs, social networking sites (e.g., Raverly.com), and the documentary film genre. Metaphors tended to reflect the technology vernacular with which participants were most familiar, whether aligning their knit-work with a journal, or comparing their recordings to pasted scraps in a scrapbook.

In contrast to most participants' explicit and careful authoring of audio annotations, Maggie, a fabric retailer in her 20s and active blogger, used Spyn to capture my conversations with her as a single audio stream. Having recently split up from her boyfriend, she described taking a brake from her "obsessive" knitting and blogging activities because she wanted to avoid reflecting or projecting her unhappiness. Intrigued by the notion of embedding conversations through her craftwork, she spoke of her knit as "bridging" her digital blogging with her physical knit garment.

It's like a blog. A knitted blog.
— Maggie

Amy, a software engineer in her late 20s, saw a connection between the invisible messages embedded in her knitwear and computational encryption. Having been interested in security for several years, Amy was eager to combine her interest in stenography with that of knitting and embedded a "secret message" into her knit using Spyn.

It's like knitting stenography — that's just the coolest thing.
— Amy

Other knitters provided comparisons to familiar, everyday technologies:

[With Spyn] I could've made almost a document, a documentary of the needlepoint I made for my granddaughter, for her wedding. Because my husband always said he took pictures of me making that… needlepoint for her.
— Esther

One of the things it reminds me of is the AIDS quilt… with each of the squares that has

memorialized someone, given some sense of who they are, but this sort of takes it further.
— Dan

Participants' comparisons to familiar tools or media provided insights into how existing technologies set precedents for participants interactions with Spyn. Three participants compared their knit to blogs and asked if they could add additional information to the knit after the knit was created or allow the recipient to embed additional messages. One participant noted that while a scrapbook invites creative sharing, a blog is dynamic and public. The media with which participants were familiar allowed participants to think creativity about future uses for Spyn.

Channels for Reflection

After using Spyn, participants often reflected on previous knitting projects and thought forward to the information they wanted to embed in future projects. One participant pondered ways in which he would use Spyn to 'enhance' a variety of past and future knitting projects. Dan was a communications director in his mid-forties and an active writer for Knitty.com (an online knitting magazine), a personal web blogger, and a member of Raverly.com (a community-driven, social network for knitters). After engaging with Spyn, he contemplated potential uses for Spyn in the lives of his co-workers, other Ravelry knitters, and his technology-phobic mother. At one point, he pulled out a sock he had recently been knitting.

Actually, I just thought of this… one the most interesting things about this sock is that I took it with me the last time that I was in New York and I met up with a friend of mine who's lived there for many years, my friend Tom, and I did not know that two weeks later he would be dead… How would I know?… He died of liver failure… At the time, I could've said, "here I am Tom, making my sock, blah blah blah blah blah." Yeah, that would've been the last time that I saw Tom.
— Dan

Similarly, Kerry thought of ways to use Spyn to embed information in an ongoing project in which she had invested significant time, labor and money. A graduate student in her twenties, she pulled out an orange sweater from her closet, and described how she had been creating it for her friend.

[My friend] Jenny specifically would think it was really cool to see the process… so she would want… that sort of cute beginning of the documentary piece where you're like 'here I am at the yarn store and I think that yarn would look really cute on you…' She would probably cry. [laughing]
— Kerry

Rather than reflect on previous projects, Penelope foresaw future uses of the knit she created with Spyn. She viewed her knit as a way to reflect on her craftwork and inspire new ideas. After showing off images of previous projects on her laptop (projects she documented with her camera), she commented on her difficulty of finding particular images collected while crafting. She compared her computer filing with the physical knit she made with Spyn.

[Using Spyn is] a good way to tag my mid-project thoughts and I could go back and… brainstorm further based on those recordings, like, 'Oh yeah I'd said this!'
— Penelope

Retrieving image, audio and video from the knit garments prompted participants to imagine ways in which their messages, comments, and images could be interpreted and exercised in the future. Such prospective uses, in turn, affected the types of information participants chose to embed.

Creative Expression

Participants demonstrated varying amounts of creativity and personal expression while using Spyn. After finishing an audio recording about her knitting techniques, Penelope described how she would be interested unraveling a finished project and knitting something new to create "an overlaid timeline" of both projects. While limited by the length of the knitting session, she wanted to finish two projects using the same thread.

Resolving to knit a scarf for her brother, Erin, a schoolteacher in her late 20s, decided to embed recipes in her scarf. She took breaks from her knitting project to cook and document her baking process. She began by baking sugar cookies and captured a video of her baking accompanied by her narration of the process. Erin's knit became a new canvas on which she could present personal messages to her brother. She noted that her brother, who enjoys cooking and lives in Montreal, would appreciate this combination of "comfort food" and "comfort" in knitting.

Intending to create the knit for herself, Amy married her personal interest in stenography with her physical knitwear. She described how she wouldn't need to carry around her credit card if she could use a bracelet encoded with her credit card number to go shopping. "[My wallet] makes the left part of my butt look fat. It'd be so nice to have this knitting." Although limited by the conditions of the field test, Amy creatively saw Spyn as a tool to embed credit card numbers into knit garments.

DISCUSSION

Before conducting field tests with knitters, I expected knitters to use Spyn to document aspects of their craft that would be similar to the recorded textual musings knitters posted to their knitting blogs or raverly.com. Such musings are relatively sparse compared to the amount of stitches in a given hand knit garment. To my surprise, three knitters who regularly craft and contribute to knitting blogs were interested in recording densely packed or continuous audio streams. They embedded streams of consciousness or conversation threads into their physical knits, recording all or most of the context surrounding their craftwork. Moreover, instead of recording reactions to their knitting, these participants recorded organic, playful musings while knitting. The recorded content, thus, became part of their making process, inviting different types of reflection.

In addition to recording unexpected content, knitters appropriated Spyn in a variety of unique and surprising ways. Erin twinned two traditionally separate creative practices, baking and knitting, by embedding a recipe for 'comfort' food into her comfortable knit. Amy combined notions of coding and knitting, resolving to transform a credit card into a bracelet. By enabling knitters to annotate their work while knitting, the knitters' created new and enhanced uses for their knit products.

After using Spyn, participants typically thought more experimentally about their knit-work, imagining future projects that spanned space, time, and knitters (e.g., visualizing projects that combine different knitters or different knit projects on the same thread). Participant also used Spyn to reflect on previous craftwork and discuss future reactions to their recorded media, suggesting that longer usage studies are necessary to interpret such embedding of information.

The variety uses for Spyn in these preliminary field tests suggests the importance of designing for interpretive appropriation (Gaver et al., 2006). Particularly in the design of creative tools, individuals may understand and use the tool in different ways. Tools for the design of electronic or print media, such as posters, e-cards, or sketches, could similarly allow users to connect their streams of consciousness to their processes of creation. If a friend of the creator had access to the message, the friend could retrieve the message layered on top of the sketch. Furthermore, the extent to which participants valued the aesthetic choices in their handwork with Spyn suggests that designers of tools for craft and e-textiles should enable the crafter to control the look and feel of the final product. Designers of technology for physical crafts such as pottery or wood-working should allow crafters to annotate or augment their work without affecting its aesthetics (e.g., attaching invisible messages for a particular set of individuals to read at a specific time and place.)

TECHNICAL LIMITATIONS

Since knitting often takes place over long periods of time, my short-term evaluation could not fully assess the potential of Spyn to enhance knitting practice. The system was sometimes slow to respond while capturing multi-media content, and the vision system supported a limited range of projects. Motivated by such technical limitations, my decision to evaluate the system during a single project across multiple locations gave us sufficient control over sensitive aspects of my system while still providing for flexible knitting environment for the use of Spyn.

Limitations in the vision system included its inability of identifying locations along projects that varied in width (stitches across) and low lighting conditions in which the IR camera images were captured. The infrared ink used to print patterns was also non-permanent: the ink washes out and fades over time, lasting and approximately eight or nine months. Surprisingly, such limitations were seen as both a benefit and a loss to participants. Some participants wanted their messages to attach to the yarn permanently while others were interested their messages having a distinct lifetime, or perspiring after eight months.

FUTURE WORK

I plan to expand my investigation of this design space in several ways. First, I intend to extend my evaluations to observe how people interact using the Spyn knitted article. How will the recipient of a knit interpret its embedded information? Due to the duration of my evaluation sessions, my evaluation of Spyn was confined to its role in the creation of handcrafted artifacts. I am also interested in exploring its use as a tool to enrich social activity of additional creative practices. Thus, I would like to investigate the potential of applying my design techniques to crafts beyond knitting, such as embroidery or crochet, as well those that extend my system, such as bookbinding or carpentry. Lastly, in order to explore a wider range of applications for my technology, I intend to improve the robustness of my system and enhance techniques for invisible printing unique barcodes on string, which can be activated by the manual capture of rich media.

This research involves studying technology's potential to celebrate handcraft and its support of social interactions through productive practice. I am interested in how new technology can support social expression in creative practice by allowing people to expand their use of the objects they create. Thus, I aim to inform the design of new tools that enhance our social, relational, and productive processes related to creative practices.

CONCLUSION

In this paper, I have explored the design of a system to enable the preservation and sharing of experience through knit artifacts. I contribute the design and implementation of Spyn, a system enabling the collection, storage, and playback of explicit and implicit data surrounding knitting processes. I report the qualitative results of short-term usage studies of the system with ten knitters and four longer usage studies with knitters over the course of one project. The emergent usage patterns I observed throughout my study complement and extend the roles of knitters as social connectors, caregivers, and sentimental gifters.

By recording contextual information surrounding knitting practice, Spyn captures and enables new forms of creative exploration and expression. Without requiring the active participation of the knitter, Spyn provides opportunities for twining contextual information with the artifact. Using Spyn, a knitter can capture rich contextual information and connect it to the physical knit artifact while knitting. Spyn addresses a largely unexplored domain of design: the infusion of technology into the production of handcrafted artifacts. Tension between these two seemingly incongruent domains of information, handcraft and computing, introduces many questions for the designer. In my design and evaluation of Spyn, I enable new avenues for creative exploration.

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REFERENCES

1. Abowd, G. D. and E. D. Mynatt. (2000) Charting Past, Present, and Future Research in Ubiquitous Computing. Transactions on Computer-Human Interaction 7(1): ACM Press. pp. 29–58, 2000.

2. Bell, G. & Gemmell, J. (2007). A Digital Life, Scientific American, March 2007. German version in Spektrum der Wissenschaft (April, 2007)

3. Berry, E., Kapur, N., Williams, L., Hodges, S., Watson, P., Smyth, G., Srinivasan, J., Smith, R., Wilson, B. and Wood, K. (2006). The use of a wearable camera, SenseCam, as a pictorial diary to improve autobiographical memory in a patient with limbic encephalitis. Neuropsychological Rehabilitation.

4. Buechley, L., and Eisenberg, M. (2008). The LilyPad Arduino: Towards Wearable Engineering for Everyone. Upcoming Wearable Computing Column in IEEE Pervasive. (Invited submission)

5. Craft and Hobby Association URL (accessed 21 April 2008): www.hobby.org/eduevents_teach.html

6. Costin, C. L. (1995) Introduction: Craft and Social Identity. Paper presented at the Craft and Social identity (Washington D.C).

7. Davis, G. R. (1997). Women's quilts and diaries: Creative expression and personal resource. Uncoverings: The 1997 Research Papers of the American Quilt Study Group, 18, 213-230.

8. Dickie, C. (2007). kameraflage URL (accessed 21 April 2008): http://kameraflage.com/

9. Eisenberg, M., Eisenberg A., Hendrix S., Blauvelt, G., Butter, D., Garcia, J., Lewis, R., and Nielsen, T. (2003) "As We May Print: New Directions in Output Devices and Computational Crafts for Children" In Proceedings of Interaction Design and Children 2003 (IDC2003), Preston, England, July 2003

10. Ferber, Rosine (2005) The psychotherapeutic and transpersonal aspects of the art and practice of hand knitting : a women's study Bauerle, L. (lead developer at Spotfire), personal communication, January 10, 2006.

11. Fields, Corey. (2004). "Throwing 'Em for a Loop: How Young Women Align Knitting to Self-Concept" Paper presented at the annual meeting of the American Sociological Association, Hilton San Francisco & Renaissance Parc 55 Hotel, San Francisco, CA,, 2004-08-14.

12. Gaver, W., Bowers, J., Boucher, A., Law, A. Pennington, S. and Villars, N. (2006). The History Tablecloth: Illuminating Domestic Values. Submitted to DIS 2006.

13. Graburn, Nelson H.H. (2004) 'Authentic Inuit Art: Creation and Exclusion in the Canadian North', Journal of Material Culture 9(2): 141–59.

14. Hartmann, B., Klemmer, S.R., Bernstein, M., Abdulla, L., Burr, B., Robinson-Mosher, A., Gee, J. (2006). Reflective physical prototyping through integrated design, test, and analysis. Proceedings of UIST 2006, October 2006.

15. Heckman, Andrea M. (2003) Woven Stories: Andean Textiles and Rituals. Albuquerque: University of New Mexico Press, 2003.

16. Johnson, J. S., Wilson L. E., (2005) "It Says You Really Care": Motivational Factors of Contemporary Female Handcrafters, Clothing and Textiles Research Journal intl-ctr.sagepub.com

17. Kirsh, D. & P. (1994) Maglio. On distinguishing epistemic from pragmatic action. Cognitive Science 18. pp. 513-49, 1994.

18. Klemmer, S. R., Graham, J., Wolff, G. J., Landay, J. A. (2003) Books with Voices: Paper Transcripts as a Tangible Interface to Oral Histories, CHI 2003: ACM Conference on Human Factors in Computing Systems: pp. 89–96.

19. Logitech Webcam URL (accessed 21 April 2008): http://www.logitech.com.

20. Macdonald, A.L. (1988), No Idle Hands: The Social History of American Knitting, Random House of Canada, Toronto.

21. Piercy, KW., Cheek, J.C. (2004). Women Aging, Tending and befriending: the intertwined relationships of quilters. 2004 – ncbi.nlm.nih.gov

22. Prigoda, E., McKenzie, PJ. (2007) Purls of wisdom: A collectivist study of human information behaviour in a public library knitting group Journal of Documentation, 2007

23. Quilton, J., & Urton, G. (Eds.) (2002). Narrative threads: Accounting and recounting in Andean khipu. Austin, TX: University of Texas.

24. Reactee. URL (accessed 21 April 2008): http://reactee.com/

25. Rekimoto, J. (1999). "Time-Machine Computing: A Time-centric Approach for the Information Environment", ACM UIST'99, 1999.

26. Rosner, Ryokai (2001) Knitter's Tapestry

27. Ryokai, K., Marti, S., Ishii, H. (2004) "I/O Brush: Drawing with Everyday Objects as Ink." In Proceedings of Conference on Human Factors in Computing Systems (CHI '04), (Vienna, Austria, April 24 - April 29, 2004)

28. Ryokai, K. and Cassell, J., (1999) "Computer Support for Children's Collaborative Fantasy Play and Storytelling", In Proceedings of CSCL 1999.

29. SiRF GPS software. URL (accessed 21 April 2008): http://www.sirf.com/free_demo.html.

30. Sterling, B. (2005). Shaping Things. The MIT Press, Cambridge MA, 2005.

31. Stoller P. 1995. Embodying Colonial Memories. New York: Routledge

32. Stifelman, L., B. Arons, and C. Schmandt, (2001) The audio notebook: paper and pen interaction with structured speech. CHI Letters, 2001. 3(1): p. 182-189.

33. Truong, K. N., G. D. Abowd, and J. A. Brotherton. (1999) Personalizing the Capture of Public Experiences. UIST: ACM Symposium on User Interface Software and Technology. pp. 121–30, 1999.

34. Whittaker, S., P. Hyland, and M. Wiley. (1994) FILOCHAT: Handwritten Notes Provide Access to Recorded Conversations. CHI: ACM Conference on Human Factors in Computing Systems. pp. 271-77, 1994.

35. Woodruff, A., Augustin, S., A., Brooke, F. (2007) "Sabbath Day Home Automation: "It's Like Mixing Technology and Religion" In Proceedings of Conference on Human Factors in Computing Systems (CHI 2007)

36. Yeh, R., Liao, C., Klemmer, S. R., Guimbretière, F., Lee, B., Kakaradov, B., Stamberger, J., Paepcke, A. (2006) ButterflyNet: A Mobile Capture and Access System for Field Biology Research, CHI 2006: ACM Conference on Human Factors in Computing Systems: pp. 571–80.