# Spyn: Augmenting Knitting to Support Storytelling and Reflection

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## ABSTRACT

Ubicomp research has spurred the exploration of more "natural" or "invisible" interfaces that can be seamlessly embedded into their environment. In this paper, we discuss the role such technology can play in augmenting existing creative practice to enhance the sharing of the handcraft process. We present the design and implementation of *Spyn*, a system for knitters to record, playback, and share information involved in the creation of their hand-knit artifacts. Guided by a formative study of knitting practices, we designed Spyn to capture information while a person knits and allow 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 messages recorded during the knitting process. Rather than seeking to improve the speed or accuracy of the knitter, we designed Spyn to enrich the knitter's craft while preserving the look and feel of the knit artifact.

### Author Keywords

Annotation, calm technology, craft, communication, handmade, process, tangible

### ACM Classification Keywords

H.5.1: Multimedia Information Systems — artificial, augmented, and virtual realities. H.5.2: User Interfaces — input devices and strategies; interaction styles; prototyping. H5.m. [Information interfaces and presentation]: Miscellaneous.

## INTRODUCTION

*Esther pulls out from her closet, her latest knitting project on which she has been laboring for several months. For her granddaughter's wedding she has been knitting a special shawl. The knit textile is composed of seemingly abstract shapes each representing a unique Hebrew prayer for her granddaughter's marriage. Now ready to knit the final section, she picks up her needles and begins to utter aloud: "This is the Mezuzah to preserve the sanctity of your home." Sitting to the side of her knitting basket, Spyn captures her voice and correlates her annotation with the area in which she now knits. For her granddaughter's wedding present she will present this shawl embedded with her oral annotations. Esther is moved by the meaning of her craft and imbues her handmade garment with explanations of its intricacies. She imagines future generations someday accessing her notes and learning about the intricacies of the pattern by replaying her personal anecdotes.*[1]

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 that particular point in time those stitches were created. Handcrafted objects are "charged" with the history, narratives, and memories of their creators as well as the people with whom they interact. [8,16]. Yet a handmade object itself cannot tell those personal stories of its making; it can just hint at the human energy poured into its creation. Information associated with handcraft is linked through intangible means: tacit knowledge and socio-cultural context encrypt a textile.

In this paper, we contribute the design of Spyn, a system to connect physical handcrafted objects with the personal experiences people have during its creation. Spyn captures information while a person knits and enables 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



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[1] This scenario is based on discussions with a study participant. Our current prototype supports the interaction methods described in the scenario. Participants' names have been changed to protect anonymity.

knitting process. Knitters keep track of their creation processes by implicitly and explicitly capturing information while knitting. By recording such information and mapping each message to locations on the physical handcrafted artifact, the crafter can control the codification of meaning within the physical textile and capture messages relating to the knitter's techniques and memories. Preliminary evaluation of our prototype suggests Spyn has the potential to preserve the crafting process while enabling new avenues for creative expression.

We first discuss our motivations for exploring techniques to enrich handcraft. Next, we introduce findings from our observations of knitting groups and discuss how they influenced our design objectives. We then outline our design process and describe the iterative design of Spyn prototypes. Lastly, we present a preliminary evaluation of our prototype with ten knitters of diverse ages and occupations.

### Craft and Technology

Malcolm McCullough describes craft as "the application of personal knowledge to the giving of form" [17]. 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 [29]. Devices designed to support historical social and cultural practices have the potential to both motivate the preservation of heritage as well as offer new opportunities for exploration. Without affecting the appearance or texture of the crafted artifact, our goal is to leverage meaningful processes inherent in handcraft while maintaining its creative end. In the design of Spyn, we investigate the preservation of hand-knit techniques while opening new avenues for creative expression.

## KNITTING

Like many domestic crafts, knitting was originally a process that employs hand-eye coordination for the production of useful goods. In the early 1900's, mass-produced fabric began to replace handmade textiles thereby decreasing the necessity for hand-knit products. In western countries, the knit craft became associated with forms of female recreation and leisure rather than with professional trade.

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

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

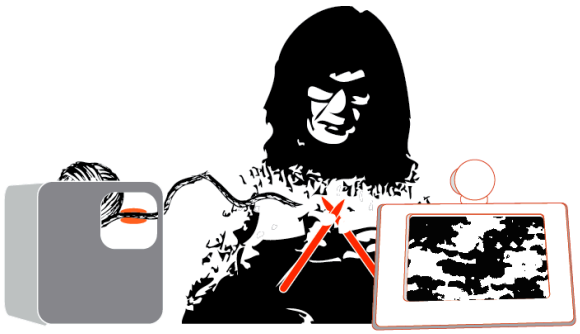


**Figure 1. Spyn enables the automatic and manual capture of information while knitting. A rotary encoder (left) keeps track of the amount of yarn pulled from its source. The mobile device stores this yardage and maps it to sensor data, such as GPS coordinates, temporal data, and media (photos, audio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

2. The motivations for knitting are characteristic of many crafts in that the knitter's objective can vary across space and time. Knitting is motivated by events, people, a need for relaxation or multiple overlapping purposes [9]. Knitters can be working on several projects concurrently, or finish one at a time.

3. The process of knitting transforms a linear artifact into a multi-dimensional textile, naturally signifying a timeline of the creation process. 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 [19]. Yet it is not always obvious to an untrained eye 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).

## CAPTURING PROCESS: ITERATIVE DESIGN

### Field study

To better understand modern knitting practice, the first author participated in four knitting circles in the greater Bay Area that each met twice a month on average over a period of three months. We participated in these knitting groups in order to observe knitters' latent needs and discover inspirations for design. The knitting circles consisted of a unique blend of professional and domestic women varying 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 brakes was composed of professional women in their late 20s to late 50s. Each group also met in a different kind 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, (sometimes over twenty in the case of the professional group meeting in a bar).

In addition to observing the knitting circle attendees, we conducted semi-structured interviews with 17 knitters, probing their crafting habits and motivations for knitting. We also had informal conversations with many other knitters in person, visited several knitting stores, and spoke with knitters outside of organized group practice.

Based on our discussions with knitters, six central themes arose:

**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 bringing lightweight projects with them as they travel, such as socks, scarves and hats, while leaving heavy projects at home, such as a large men's sweater made of denim. We also observed that while traveling, knitters carried a bag or basket supplies for their project.

**2) Invested time:** 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 also reported having several knit projects ongoing in parallel, tucking away half-finished knits in closets in the hope of future completion.

**3) Occasions and opportunities:** Knitters spoke of being motivated by a variety of phenomena: a gift for a particular person, 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).

**4) Process:** Knitters are not only enjoying the product of their activity, but also the process of the knitting activity itself. Some knitters reported the therapeutic aspect of knitting, which involves physical interaction with soft and comforting materials. Some knitters also discussed the rhythms of needles "dancing" in their hands being perfect for their nervous hands and perceived productivity.

**5) 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. 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 images to a website, and sometimes overlay written annotations on the image.

**6) Personal yet social:** Knitting activities happened both in personal space (e.g., on the couch at home) and in social space (e.g., at café with friends, in knitting circles). When knitters met with their fellow knitters, narratives were abundant. Storytelling evolved both around the process (e.g., sharing techniques and tools of trade) and the product (e.g., gossip and personal narratives inspired by their knit projects).

## Design Principles

Motivated by insights from our fieldwork, we came up with the following principles for the design of our system:

### 1. Capture

**Capture Progress**

*Research Insight:* The amount of yarn used is direct evidence of how much progress a knitter has made.

**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.

### 2. Connect

**Connect to the process**

*Research Insight:* The physical knit artifact is disconnected from a knitter's experience of its creation after the knitting process.

**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.

**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, both technical and social.

### 3. Make Seamless

**Calm technology / Remain lightweight**

*Research Insight:* Knitters were able to control the locus of their attention, seamlessly moving it from their knitting to their social environment. Some knitter's described knitting in public spaces, yet shutting out their environment.

**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.

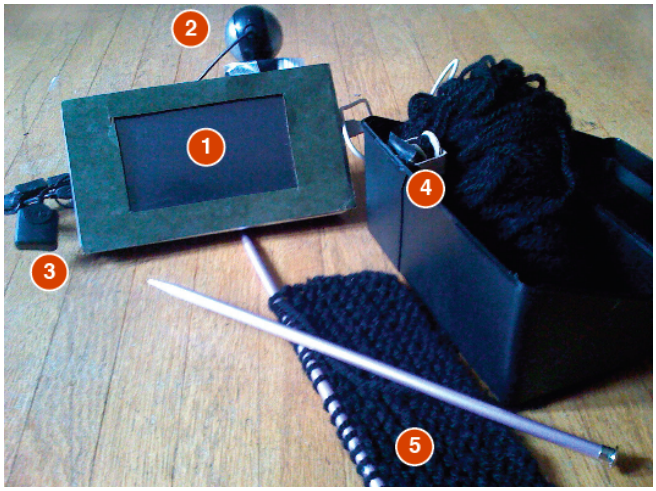



**Figure 2. Components of *Spyn*: 1) Mobile computing device with display screen 2) IR enabled camera for video, image and sound capture (also used as a scanning device), 3) and 4) sensors for automatic data collection (GPS device and encoding length of yarn), and 5) yarn printed with invisible IR ink.**

## 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. Her yarn is pre-printed with patterns of infrared ink, invisible to the naked eye. She touches a record button on her mobile device, and speaks aloud: "This one is for you. Happy birthday, Tim!" 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, Tim, 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 completed in time for Tim's birthday. When Tim receives the hat, he photographs the rim using his mobile device and pointers appear mapped on top of the image of the knit (see Figure 5). He touches the image and watches a video of his friend at a cafe describing her unnatural purling. Tim is excited to watch his friend at the time she created hat. He is touched by the uniqueness of the gift and knowing that the hat was created just for him. He ponders what he will use Spyn to create for his friend in return.

## IMPLEMENTATION

Our prototype is comprised of a mobile computing device receiver (Asus Ultra Mobile PC) with touch screen interface and built-in GPS, see (1,3) in Figure 2. The device is connected through USB to a Phidget encoder, a USB mechanical rotary device that encodes digital output (4) and an infrared enabled camera (2). Although the system's capture and recall functions worked for the purposes of our field studies, our prototype was not intended to be a complete technical solution.

### Yarn and Resolution

We used infrared 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 (in cm) minus the varying amount of yarn occlusion (in cm), which changes based on the tightness and complexity of the knitting stitch. In practice, we have found the system is generally able to detect positions within one inch of the area on the knit image; in cases where the yarn was not pulled through the rotary encoder in between data capture, the system is able to detect positions within three inches of the area on the knit image.

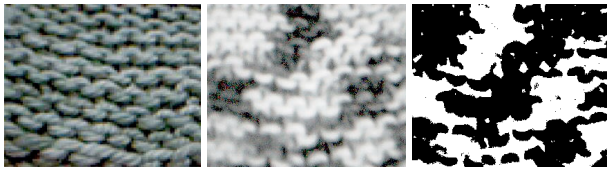
### Software and Vision System

The core system and user interface were written in Actionscript 3.0. The system uses SiRFDemo [25] for logging GPS data and Logitech® QuickCam software [15] 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 infrared (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 (i.e., 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. The vision algorithm assumes no other IR emitting or reflecting objects are in the scene at the time. Image analysis is done on the IR channel to recall the collected data. For every image of the knit used to access information, we produce a matrix with the same dimensions as the image (in pixels); each entry in the matrix is initially a 0. We 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, we produce a matrix of 0s and 1s corresponding to the area of the image in which the yarn was coated with infrared ink. We then average pixel values across both

dimensions (rows and columns), calculating the gradient value of the differences between these pixel averages for both dimensions. We use the gradient value to determine the "knitting" direction in the image. Next we correlate the stored percentages of yarn pulled through the encoder (Y) with corresponding averaged matrix values. Finally, we map information associated with each Y value onto its correlated position in the original image of the knit.

Spyn introduced several implementation challenges that merit further discussion. First, our vision techniques prevented us from properly evaluating the accuracy of the system's recall functionality. The vision system did not take into account other IR emitting or reflecting objects in the scene, the illumination of the knit, the distance or viewing angle of the camera in relation to the knit, and the possibility of encountering overlapping periods of production time within an area of the knit. Nor did the vision system account for changes in the size, shape or orientation of the knit. During our user studies, participants knit linear artifacts in well lit locations and were able to include the whole knit in the photograph during recall. In order to address these issues, we must increase the sophistication of our vision algorithms in future work and evaluate the recall accuracy using different yarns, lighting conditions, and relative camera positions on different knit projects. Additionally, the implementation of the recall system relied on the permanence of the IR ink printed on the yarn. Since the IR ink significantly fades after a maximum of nine months, the current system cannot support long-term practice. Additional preservation techniques, such as annotated digital representations of the knit project, can be developed to support the continued accessibility of each project.



(a) Normal view (b) IR camera view (c) Vision system view

**Figure 3. One garment shown in three views used in Spyn. The IR ink is invisible to human eyes (a). Invisible infrared ink is captured by our IR enabled camera (b). Processed image (c).**

## INITIAL PROTOTYPE

We developed our first prototype to provide automatic capture of position data and enable explicit authoring of image 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. Image data was automatically associated with its temporal location in the knit artifact.

Our initial concept for viewing the knitter's collection of data consisted of three views: 1) a dynamic display of *yarn* (Figure 4a), 2) a *map* of the knitter's location (Figure 4b), and 3) the knitter's *garment* augmented with markers indicating areas on the garment associated with collected data (Figure 5). The *yarn* view provided Spyn's default display while a person knit, and the *garment* view and *map* view were accessible via buttons on the knitter's default screen. We describe each in turn.

The knitter's *yarn view* consisted of two skeins (or balls) of yarn in which a person's process of knitting triggers one skein to feed into the other (see Figure 4). The *yarn view* served as a simple metaphorical representation of a knitter's time knitting using Spyn.

The knitter's *map* view consisted of a map of the area in which the knitter was using Spyn. Highlighted points on the map indicated locations in which the knitter had captured data. The size of those points (represented by small balls of yarn) was correlated with the amount of yarn used at each location. The knitter touched a point to access data collected at a given locations.

The knitter's *garment* view enabled both collection and access to data. To collect image data, knitters would use this view to collect images. Spatiotemporal data was collected when an image was captured as well as at 3-yard intervals (in order to provide a fairly high level of granularity relative to the amount of yarn used during our initial evaluations—i.e., 10-20 yards). To access the data, knitters point the Spyn device at their knit and capture an image of their knit. Following this, the device would visualize points on the kit garment at which data had been associated while knitting (see Figure 5). The spatiotemporal data was also visualized on top of the image of the knitter's garment.

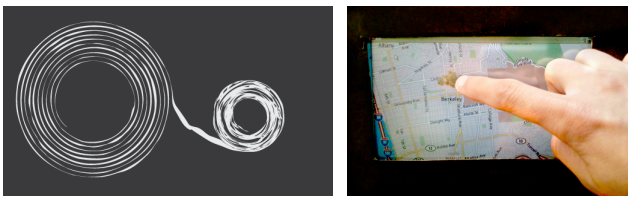


**Figure 4. *Yarn View* (left) used the visual metaphor of the knitter's ball of yarn. *Map View* (right) presented knitter's journey generated by the system.**

## FIRST EVALUATION

We conducted two evaluations during our development of Spyn: a first evaluation with ten knitters using our first prototype; and a second evaluation with four knitters using our second prototype. Our evaluation of our first prototype was conducted at a single location in one to one-and-a-half hour-long sessions. Guided by our early fieldwork, we recruited ten knitters to participate in this preliminary evaluation. Participants were all female and ranged in age from mid-20s to late 70s, (over half were above the age of 40). Two of the ten knitters were in their 70s and retired, whereas the remainder were working female professionals. Sessions involved knitting part of a larger project, typically a scarf.

From these first evaluation sessions, we learned that knitters enjoyed interacting with the *garment* view,

touching highlighted points on Spyn's image of their knit. While accessing information within the *garment* view, we observed knitters wanting to *directly touch* highlighted marks on the knit (see Figure 5). However, the points on the knit highlighting manually collected images were often difficult for knitters to distinguish from the points highlighting automatically collected data (such as data from GPS and encoder devices). Moreover, such automatically captured data was less interesting to knitters unless it was associated with their collected images. Some knitters relayed additional difficulties in reading the data placed on top the image of their knit.

Although most knitters were eager to view images they collected by accessing highlighted points in the *garment* view, knitters were generally confused by the *yarn* view and indifferent to the *map* view. Knitters looked at the *yarn view* but did not use it to navigate their progress (Figure 4). Knitters reported finding the *yarn view* redundant (knitting progress is already displayed by their ball of yarn), and abstract (lacking connection to their physical knits). These findings led us to remove the *yarn view* from our second prototype.

Several knitters expressed an interest in recording data relating to their technical process, such as the amount of yarn used, and annotating their knit through video. Since the knitting process involved constant use of the knitters' hands, knitters expressed an interest in capturing image, video, and audio data over written information, which imposes more physical demand.

**Figure 5 *Garment View* (left) allowed knitters to access information associated with physical knit by touching points on captured an image of the knit. Touching the image enlarges the captured image (right).**

## SECOND PROTOTYPE

From our initial observations, we learned that one major limitation of the first prototype was associating too much information with the knit. We altered the main interface accordingly and only visualized points in the knit at which data was manually captured, presenting automatically captured data in connection to those points when accessed. Based on participant feedback, we also replaced Spyn's default screen—the *yarn view*—with a view of the knitter's physical artifact overlaid with the knitter's progress (as yarn yardage)—the *garment view*. We also enabled video recording in addition to digital photography in our second prototype so that knitters could record descriptions of their knitting and activities around knitting by means other than writing. Although knitters were uninterested in the *map* view, our initial evaluation was limited to one location and did not consider the portability of the knitting craft. We addressed this constraint in our second evaluation.

Akin to the first prototype, the second prototype automatically recorded GPS data and the amount of yarn used; it required no active use from participants beyond their existing knitting practice. In addition to images from the first prototype, knitters could manually capture video and audio. Spyn automatically associated such data with locations along a ball of yarn. To access the stored data, participants used the *garment view,* pointing the device at the knit garment and touching 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) associated with each marker.

### Accessing Data

In response to knitters' difficulties reading the data placed on top of the image of their knit in our initial evaluation, we improved the visibility of data by moving the text and image to a static location at the edge of the screen (Figure 4a). Because knitters were relatively uninterested in spatiotemporal data detached from manually collected data, we only displayed position data in association with the manually collected data.

During our first evaluation, most knitters in our first evaluation did not use the *map view* because their experience with Spyn was limited to one knitting session at one fixed location.

Finally, because of the short duration and single spatial location of our initial evaluations, we were not able to properly understand what kinds of information people embedded in their knits. This led us to conduct our second evaluation with four knitters over a longer period in which knitters were able to travel to multiple locations that were of personal significance to them.

## SECOND EVALUATION

We present details from our second prototype and evaluation conducted at participants' favorite knitting locations in half day sessions. We evaluated our system with four knitters, two of whom had been introduced to our initial prototype in our initial evaluation. The knitting sessions involved: 1) semi-structured interviews regarding personal knitting practices, 2) a first-use trial period in which the participant learned to use our system to capture and access data (only conducted for the two participants unfamiliar with the system), and 3) a knitting session in which the participant created a knit article using our system. Each session typically lasted a half-day and took place in three or more locations in which the participant normally knits. For three of the four participants, one location included the participant's home.

## RESULTS

Participants' engagement with our system for an extended period of time provided us with more detailed feedback. Each participant demonstrated a distinct use of the system, using Spyn for *reflection*, *preservation*, *personal storytelling*, and *creative inspiration*. We describe each session in more detail and discuss participants' use of our system relative to their existing knitting practice.

### Katie: The Reflector

*Personal meaning of craft practice was of considerable importance to Katie, offering her unexpected opportunities for self-reflection.*

*Katie,* a new graduate student in her early 30s, typically knits several times a week in a variety of environments. She knits by herself, yet thinks fondly of her late mother often while she knits. Her mother taught her to knit as a child, and when her mother passed last year she stopped knitting for several months. Since that time, knitting has been charged with positive association of her mother's life and craft.

Katie initially captured images of her outdoor environment at the university in which she recently began her graduate studies. Once she returned indoors, she photographed her knit in order to access the images she collected outside. The images prompted Katie to reflect on her relationship to this relatively foreign environment: "I've been so busy that I haven't had time to realize that I'm in this new place." The images were an explicit reminder of her recent life transition, bridging her process of reflection to her process of handcraft. She also spoke of how the object demonstrated the time and effort devoted to the making of articles by hand. While accessing images, she referred to her knit garment as like "emotional blackmail," describing how this generation of her family does not appreciate the privileged lifestyle they lead.

**Figure 6 Participant accesses her stored images.**

### Esther: The Preserver

*Esther spoke about the importance of preserving personal associations with her craft and crafting techniques in connection with specific areas on her physical textile.*

*Esther*, who has knit for over 60 years, articulates the significance of maintaining familial and cultural bonds through her craft. Now retired and approaching her mid 70s, she has many ongoing projects that she keeps in her closet and retrieves for various purposes. She describes of a particularly meaningful project in which her husband documented each area of her craft for the special occasion of her granddaughter's wedding. She demonstrated how she could use Spyn to preserve particular motivations behind the creation of her craft. Esther's wish to document these stories is driven by her desire to preserve her Jewish heritage as well as prepare for the future life of these objects after her death.

While using Spyn, Esther described struggles she experienced in producing her craft. Spyn connected these anecdotes to their related physical form. Such oral description preserved in the knit allowed Esther to physically connect the value and cultural significance of her creation.

**Figure 7 Ester's spoke of herself as a perfectionist and clarified her disapproval by photographing a mistake in her knitting (left); captured image of her mistake (right).**

### Karen: The Storyteller

*Karen documented stories while knitting and expressed a desire to embed a narration of her entire creation process into her knit artifact.*

*Karen* is a third-year doctoral student in her late 20s. She learned to knit from her grandmother and often knits alone in public spaces in order to relax. Last year she began knitting a turtleneck for a close friend but has yet to finish the project. During her first-use of Spyn she imagined capturing the story of a knit object for a gift for her friend. Once she became more familiar with the system, Karen wished to document her experience of creating the gift from beginning to end, imaging that her friend, another knitter, would love to access stories associated the knit, from her descriptions of her choice of yarn and pattern to meaningful fragments of her daily life. She began knitting in a café in the city, and continued capturing aspects of her knitting at her home. Her messages to her friend included her descriptions of how she would want the article to look on her friend and her envisioned other projects she intends to create.

### Erin: The Inspired Crafter

*Erin used Spyn as a new medium for creative expression.*

*Erin* is a middle school teacher in her late 20s. Her grandmother taught her to knit when she was young and she often thinks of her grandmother while she knits. Erin associates the practices of both cooking and knitting with the comfort of her home.

Early in her knitting session, Erin resolved to knit a scarf for her brother. Since her brother enjoys cooking and lives in Montreal, she decided to embed recipes of "comfort foods" in her scarf by taking breaks from her knitting

project to cook and document (through photograph) different "comfort food" recipes. She began by baking sugar cookies, and capturing images of her baking process along with her narration of the process. Erin's knit became a new canvas on which she could present personal messages to her brother. Using Spyn, she formed an explicit, physical connection between two traditionally separate gifts: her baked cookies and her knit scarf. These parallel hand-made products merged into one. By enabling the connection of separate customs within a single physical artifact, Spyn inspired unique forms of creative practice.

**Figure 8. Erin embeds her recipe for "comfort food" into a knit she intends to give her brother in Montreal. She uses both image and video capture to document her project.**

## SUMMARY

Focused half-day sessions with four knitters gave us more insights into how our system supports the documentation of knitting practice. Each knitter used features from our system to record a unique experience of their creation, weaving personal meaning into their physical knits. Although the motivations behind their craftwork differed, they each used Spyn to augment social practices inherent in their craftwork. Esther's desire to create "heritage" for future generations reflected the importance she placed on the interpretation of her craftwork, preserving the value she places on particularly "beautiful" craftwork. Whereas Erin and Karen used Spyn around the city, and Erin captured aspects of her baking activities to communicate caring and "comfort" to her brother. In each case, these preliminary evaluations suggest that our system has the potential to extend the social uses of this traditional recreational practice.

## DISCUSSION AND RELATED WORK

From our design process and preliminary field tests, we found several directions for future research that deserve additional discussion. These themes may enable the Ubicomp community to better understand the design of new tools for creativity and recreation.

### *Directed Appropriation*

Ubicomp researchers have suggested the importance of designing for interpretive appropriation wherein the technology supports multiple interpretations of its use [11, 23]. The History Table Cloth [11], for example, electronically highlights how long objects have stood on top of it. The cloth provides traditional protection and aesthetic appeal while encouraging reflection at the dinning table. Technologies that augment traditional creation practices have similarly established the potential of fostering artistic expression while painting [21] and storytelling [22], and reflection while prototyping [13]. The design of Spyn reinforces the importance of familiar constraints to direct a creator's goals, values and methods that, in turn, promote reflection and creativity.

### *Social Uses of Capture and Access*

Spyn reveals how Ubicomp capture and access techniques can be applied to the domain of knitting to connect the creation process of an artifact with the digitized telling of its story. While life-logging technologies like "SenseCam," [24] function autonomously, other multimodal note-taking systems enable both manual and automatic control [14, 26,27,28] including a system for field biologists to correlate handwritten notes and photos to physical specimens [30]. Tools that link digital media to physical objects such as garments [6] must renegotiate this control in each application domain.

### *Celebrating Recreational Practice*

In contrast to designing corrective technology to fix problematic behavior, recent HCI research has advocated the design of new technology to celebrate successful, existing practices [12], such as recreational activities related to the home [2] and craft [1]. The Spyn system explores this enhancement by augmenting the experience of craftwork without requiring changes to the finished product or the production process. Knitters used the system to celebrate their handicraft with digital annotations, combining their craft with other personal practices.

### *Demonstrating Craftsmanship*

In order for a knitter's work to feel fulfilling, the knitter must be able to demonstrate her skills, invested time, and choices of material and pattern. These dimensions of the creation process impact the social value of the artifact, whether making a warm sweater for the winter or a handmade scarf for a friend. Ubicomp technology can advance the delivery and consumption of creative goods by revealing the craftsmanship invested in the product. Tools for the delivery and reception of physical and digital gifts can present aspects of the creator's authorship, such as receiving electronic greeting cards at meaningful geographic locations or attaching personalized digital images to a delivered bouquet of flowers. Reactee [20] is a service that allows people to design personalized T-Shirt prints that include a phone number that other people can text message. Thus, by connecting expressions of craftsmanship to benevolent interactions we may allow people to enhance the value of creative goods they transfer to others.

### Limitations

Limitations in the technical implementation of our system produced conceptual challenges. Since knitting often takes place over long periods of time, our short-term evaluation did not fully assess the potential of our system to enrich knitting practice. Our decision to evaluate our system during a single knit project across multiple locations gave us sufficient control over sensitive aspects of our system to provide a flexible knitting environment from which interesting uses could emerge.

Evaluating the recall experience using our current prototype was also a challenge. In the existing implementation, the knitter's data is stored on the individual's mobile device and the recipient of the knit needs the same device to access the associated information. To address this issue, we are currently developing the system on a cellular phone platform in which the data is stored on a central server ("in the cloud") and made accessible using a lightweight client application running on a recipients cell phone. We envision the cell phone equipped with an IR-enabled camera, and GPS or similar position sensing capability.

### Future Work

We plan to expand our investigation of this design space in several ways. First, we intend to extend our evaluation to observe how people interact using the knitted article produced with Spyn. We want to better understand how the recipient of a knit interprets the embedded information. Due to the duration of our evaluation sessions, our evaluation of Spyn was confined to its role in the *creation* of handcrafted artifacts. We are also interested in exploring its use as a tool to enrich social activity of additional creative practices. Thus, we would like to investigate the potential of applying our design techniques to crafts beyond knitting, such as embroidery or crochet (which use linear thread that could be printed with patterns of IR ink), as well crafts that extend our system, such as bookbinding or carpentry (which require new techniques for connecting the digital annotations to the material). Lastly, in order to explore a wider range of applications for our technology, we intend to improve the robustness of our system and enhance techniques for invisible printing unique barcodes on string, which can be activated by the manual capture of rich media.

Our research involves studying technology's potential to celebrate handcraft and its support of our social interactions through productive practice. Thus, we are interested in how new technologies can enrich social expression by expanding people's use of the objects they create. In the future we aim to inform the design of new tools that enhance our social, recreational and productive uses of creative practices.

## CONCLUSION

In this paper, we have explored the design of a system to enable the preservation and sharing of experience through knit artifacts. We contribute the design and implementation of *Spyn*, a system enabling the collection, storage, and playback of explicit and implicit data surrounding knitting processes. We 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 we observed throughout our study complement and extend the roles of knitters as social connectors, caregivers and sentimental gifters.

By recording rich 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 our design and evaluation of Spyn, we enable new avenues for creative exploration.

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