StitchFlow: Enabling In-Situ Creative Explorations of Crochet Patterns With Stitch Tracking and Process Sharing

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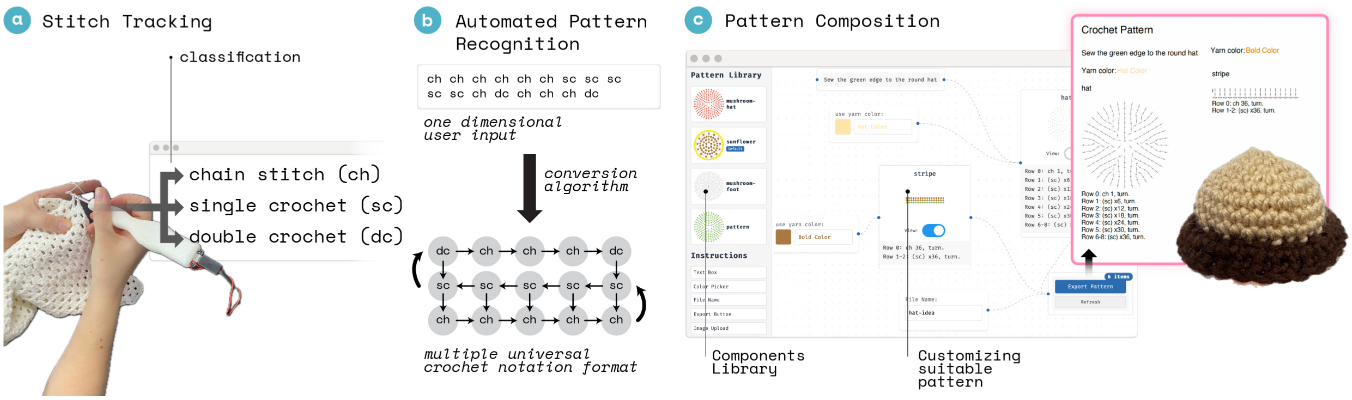

Figure 1: StitchFlow supports in-situ creative explorations by recording the user-made patterns in the background, facilitating easy pattern editing and sharing through real-time sensing through a crochet hook with an embedded sensor, tool for pattern recording and editing, and canvas for project documentation composition that can be exported, ready to share.

Abstract

Crochet is a tactile craft that has resisted automation, remaining a manual activity characterized by improvisation and adaptation. While crafting, practitioners enter a state of creative flow, becoming fully immersed in their work. However, tasks like documenting patterns, tracking progress, and backtracking due to mistakes or mid-process changes can disrupt their creativity flow. Drawing on the concept of creative flow, a state of total engagement with clear goals, immediate feedback, effortless attention, and spontaneity, we build StitchFlow. This system enables crocheters to remain immersed in their craft while automatically constructing process documentation and allowing them to edit and share it in multiple ways. StitchFlow supports in situ stitching without distraction or the need to remember previous steps using a motion sensor to track real-time hand gestures and reconstruction of the stitch pattern. The created designs can be viewed, edited, and combined, promoting variation-making and design alternations through a graphical interface. To foster the sharing of the results with others, the system supports composing and exporting the documentation using traditional methods like written patterns and crochet charts or as flows that other users can follow within the system. Through user studies with 8 crocheters, we found that StitchFlow preserved makers' creative flow, enabled spontaneous exploration, and facilitated pattern sharing.

CCS Concepts

• **Human-centered computing** → **Interactive systems and tools**.

Keywords

Digital Fabrication, Crochet Patterns, Design Tools

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1 Introduction

Crochet is a highly manual and tactile craft in which fabric is created by interlocking loops of yarn with a hook[2]. Unlike other textile techniques, crochet has uniquely resisted mechanization and automation—there are no machines capable of fully replicating the hand movements required to manipulate stitches [28]. Instead, crochet remains an inherently human skill, practiced through improvisation, iteration, and adaptation to materials and personal styles. Beyond its artistic and functional value, crochet contributes

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to well-being, fine motor skill development, and social connection [29, 30, 34]. Once primarily a domestic craft used to create practical items, crochet has evolved into a modern art form with strong ties to sustainability, as practitioners embrace fabric crochet and upcycling practices to create eco-friendly products [14]. The increased accessibility to online tutorials has dramatically broadened the scope of crochet, encouraging artisans to create everything from intricate garments to Amigurumi toys and large-scale installations, transforming it into a versatile and sustainable medium that appeals to diverse audiences[36]. The relationship between crochet and computation has gained increasing recognition in recent years. Researchers have drawn parallels between crochet patterns and algorithmic processes, highlighting how the sequential nature of stitches mirrors computational thinking [35, 40]. This connection is exemplified in works like "The Crochet Protocol," where crochet instructions are algorithmically generated and transmitted through vibration signals [40]. The structured yet creative nature of crochet—with its defined operations that can be combined to create infinite variations—positions it as a unique computational medium that bridges traditional craft and digital expression.

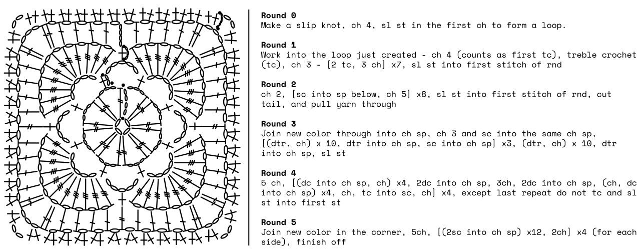

Figure 2: Different traditional crochet representations: written instructions and corresponding chart pattern utilizing domain-specific abbreviations and symbols.

Despite these computational parallels, recording and documenting crochet patterns remains a significant challenge that often disrupts the maker's creative flow [10]. Crochet patterns are commonly shared in flat representations such as written notation [7] and symbol-based charts [8], with proficiency in one format not necessarily translating to fluency in the other (see Figure 2 for an example). Documenting a crochet pattern typically requires makers to pause their process, count stitches, take notes, and mentally interpret notations. These interruptions break the immersive flow that is essential to creative exploration. This is especially challenging in crochet, a craft that often relies on improvisation and real-time adaptation, where insights emerge through tactile engagement with the materials rather than through preplanned design [32].

While digital tools offer new possibilities for capturing crochet patterns, most existing approaches fail to support the maker's creative flow. For instance, Spyn [31] explores capturing the stories and memories embedded in knitted objects through digital recording, highlighting alternative ways of documenting and sharing making process beyond pattern representation. Projects like AmiGo [11] demonstrate computational approaches to generating crochet patterns from 3D models, and Hybrid Crochet [17] explores digital fabrication integration, but these solutions typically separate the design process from the immersive, tactile experience. Unlike knitting, which benefits from domain-specific languages like KnitScript [19], crochet's resistance to mechanization requires an approach that complements rather than disrupts its inherently nonlinear creative process [32]. Digital tools can meaningfully support the creative process, amplifying the maker's intent through hybrid practice [3, 41]. As noted by previous work, "The lack of rich tool support leads to increased manual effort for pattern designers and challenges for crocheters due to erroneous, incomplete, or ambiguous patterns. Even when using the existing tools, designers have to manually arrange graphical stitch symbols as if working in a general-purpose graphics editor" [33].

To address this gap in rich tool support for pattern documentation, we present StitchFlow, a system that enables real-time, in situ crochet pattern tracking through a combination of real-time motion sensing and an interactive editing tool. By embedding a motion sensor into a crochet hook, our system detects stitch types as they are made, allowing users to explore designs without breaking the creative flow (Figure 1). Rather than requiring meticulous manual recording, StitchFlow automatically structures patterns, which users can later refine using a visual editor that supports multiple pattern representations, including written notation, node-based diagrams, and color-coded visualizations.

This paper contributes:

- An interactive system for in-situ crochet pattern support, combining real-time stitch detection and flexible editing tool that allows users to reflect on, refine, and share their design.
- A new interaction approach for crochet, demonstrating how motion sensing can be used to support creative exploration without disrupting the process, including open-sourcing system and dataset of crochet motion.
- Empirical insights on real-time pattern tracking via a user study with 8 participants in a semi-realistic creative task using StitchFlow system, revealing how automated sensing affects the way crocheters develop and refine designs.

Through this work, we explore how digital augmentation can enhance creative craft practices without imposing rigid structures, bridging the gap between physical making and digital reflection [6]. By prioritizing in-situ interaction, StitchFlow enables crocheters to design freely, while ensuring they can revisit and iterate on their creative process.

2 Related Work

Traditional craft practices have increasingly gained interest in Human-Computer Interaction (HCI), leading to the development of digital tools that enhance making. While crafts such as knitting and ceramics have seen significant integration of computational design and fabrication, crochet remains largely manual. Our work builds on prior research by bridging this gap, offering a system that supports in-situ creative exploration for crochet. This section reviews dcro-createigital augmentation tools designed to support craft practices, with a focus on crochet in HCI and broader computational craft tools.

2.1 In-Situ Support for Making

In many crafts, systems have been developed to support practitioners during the act of making, offering real-time input, feedback, or guidance.

For example, the Digital Pottery Wheel [24] integrates the process of manual throwing techniques and clay 3D printing, blending human and machine making processes. SketchPath [13] allows ceramic artists to draw tool paths for clay 3D printing, to create organic shapes drawn by hand. Nissen et al. [27] created a system that transforms making processes into physical artifacts to embed new meaning and encourage reflection. Albaugh et al. [1] augmented a hand-operated knitting machine to record the crafting process and provide immediate feedback on the machine's use and affordances. Similarly, Needle User Interface [25] captures real-time needle insertions in embroidery using conductive fabric to give real-time user feedback.

Within crochet, "The Crochet Protocol" [40] is an in-situ instruction transmission haptic wearable, guiding crocheters stitch-by-stitch. While it maintains a real-time connection, it frames the maker more as a follower than an active creator. Cro-Create [5] explores the idea of gesture recognition for auditory feedback and explores a new meaning to collaborative crafting in real-time, though it emphasizes synchronization between leader and follower over creative autonomy. Hybrid Crochet [17] integrates physical, 3D-printed guides into the crochet process, subtly augmenting the act.

Example works augmenting clay 3D printing with human touch explore new modes of expression through human and machine collaboration [13, 24]. Although these works support embedded making and creativity, they depend on a precise machine, which is not the case in crochet where true crochet machines that recreate hand movement are not yet possible [15, 28]. Prior work on recording the making process has primarily focused either on providing guidance and feedback to ensure procedural correctness [1, 25], or on generating reflective artifacts post-process [27], without actively supporting real-time creative exploration.

Although there exist approaches exploring real-time augmentation of crochet, they add feedback to pre-planned making in forms of vibration [40], sound [5] or fixed guides [17] and do not support in-situ creative explorations.

2.2 Creative Tools and Generative Support

Across crafts, creative tools help makers experiment with novel forms while retaining traditional processes. PaperCut [38] lowers the barrier to 3D design with intuitive paper templates, while KnitScript [19] allows machine knitting through scripting, enabling pattern exploration through code. In ceramics, CeramWrap [37] supports surface design on pottery using digital workflows, blending creativity with fabrication.

In crochet, Generative Crochet [35] explores creative support through an algorithm that randomizes crochet patterns, encouraging the exploration of unconventional forms. AmiGo [11] is capable of converting 3D models into crochet patterns, though this happens before the act of making, rather than as a response to emergent ideas mid-process. Similarly, Knitty [21] generates crochet patterns from user-sketched 3D surface models and presents step by step instructions of the pattern.

These systems show promise in enabling creative explorations, but these tools remain separate from the embodied act of crafting, failing to support in-situ creative explorations.

2.3 Pattern and Craft Language Support

To support communication and documentation, various systems formalize craft patterns and introduce computational representations. In knitting, KnitPick[18] interprets hand-knitted textures into structured KnitGraphs, while Twigg-Smith et al. [39] introduced a direct manipulation tool to abstract independent design elements. Craft-Aligned Scanner [23] in ceramics supports real-time patterning by scanning hand-crafted elements with digital design tools.

In crochet, Digital Crochet [33] introduces a graph-based language for structured patterns, improving clarity, while Guo et al. [16] provides a mesh-based system representing yarn geometry. Both formalize the craft but are oriented towards manual documentation and simulation. Similarly, AmiGo [11] provides structured outputs from 3D models, though again assumes a predefined design.

In terms of pattern support, our work most aligns with the goal of Craft-Aligned Scanner [23], as we want to support automated translation between a hand-crafted object and a computational representation. Although these approaches provide a groundwork for interpolating computational representations of craft, they remain largely disconnected from the creative rhythms.

3 System design

Our system is designed to support the creative flexibility inherent to craft through real-time crochet pattern recording and interactive pattern composition. We focus on enabling in-situ creativity, maintaining workflow continuity, and facilitating pattern documentation and sharing.

3.1 Walk-through: Designing a Key Chain with StitchFlow

To illustrate the system's workflow and design rationale, we present the design journey of Anna, an experienced crochet artist creating a key chain using a crochet hook with an IMU embedded inside that tracks her hand motion, a foot switch that explicitly signals the system about stitch being made, and StitchFlow interface (Figure 3).

Walk-through *Anna is an experienced crocheter who enjoys creating cute accessories. Rather than working with predetermined patterns, Anna prefers a more exploratory approach, shaping her ideas as she crochets. She begins with a general concept but remains open to spontaneous adjustments. Inspired by a key chain she saw earlier, she picks up her motion-sensing crochet hook, connects it to the StitchFlow web interface via a USB cable, and begins crocheting.*

3.2 Exploring Ideas With Real-Time Sensing

Maintaining creative flow is essential in crafts, where ideas often emerge through hands-on engagement with materials. Traditional crochet pattern recording methods require makers to periodically

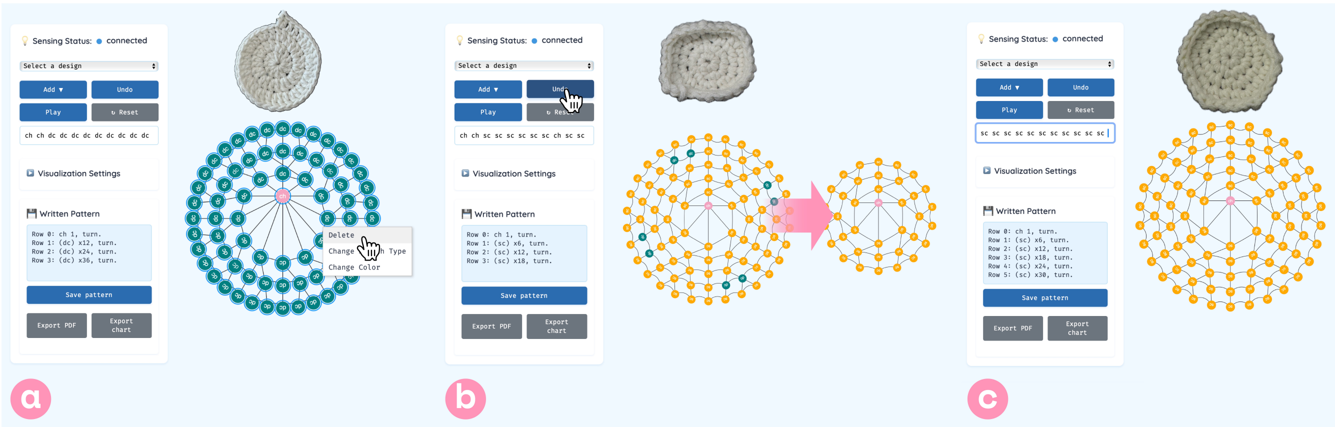

Figure 3: As users experiment with different shapes, StitchFlow captures their progress in real-time with a motion-sensing crochet hook and foot switch (left). Examples include: (a) round and flat form, (b) square and three-dimensional shape, and (c) round and three-dimensional structures.

pause and reconstruct their work retrospectively, disrupting the flow and introducing the risk of errors. To preserve the immediacy of the creative process, our system provides non-intrusive, real-time documentation through stitch tracking. By embedding motion sensing directly into the crochet hook, stitches are captured as they are performed, eliminating the need for manual recording. This integration allows documentation to occur seamlessly alongside creation, supporting uninterrupted exploration and improvisation.

Walk-through: *Anna begins designing her key chain by freely experimenting with simple forms, letting the shape emerge as she crochets. As she works, the system captures each stitch in real-time, dynamically visualizing the structure on the interface. Her first attempt is a flat circle made entirely of double crochets (Figure 3.a), but she finds the shape too predictable and one-dimensional. She unravels the yarn in the act of "frogging." Due to the structural nature of crochet, correcting a mistake requires ripping out all subsequent stitches, making the process repetitive and often frustrating. She deletes all stitches she made until now through in the interface (Figure 3.a). Curious to try something more sculptural, she switches to single crochets and begins shaping a rounded form. After the second round, she experiments by inserting double crochets at four points, subtly stretching the structure into a soft-edged square (Figure 3.b). While the result feels more dimensional, she finds it too rigid for the soft, playful aesthetic she's aiming for. Throughout this process, the system continuously records her stitch sequences, allowing her to pause, reflect, and return to earlier versions as new ideas surface. Anna backtracks her design to the round before she added corners (Figure 3.b).*

Real-time documentation not only eliminates the need for manual tracking, but also enables a fluid rhythm of creation, reflection, and refinement. Because the system records each stitch as it happens, makers can pause freely and step back to evaluate the emerging form without fear of losing progress. The mental load used to memorize the stitch structures and numbers can then be allocated to other creativity-driven aspects of crochet like forms and functionality of the crochet piece. This continuous record allows them to revisit earlier attempts, compare variations, and branch off into new ideas without having to start over. For crafts like crochet, where patterns often emerge through experimentation rather than pre-planning, this supports a more natural, iterative design process. Pattern documentation becomes an embedded part of creative exploration, rather than an interruption to it.

Walk-through: *Finally, Anna lands on a round form with a slight taper, a dome-shaped base that begins to suggest new possibilities (Figure 3.c). As she watches the shape emerge simultaneously in her hands and on the interface, it reminds her of a cap. The soft, organic curves spark an idea: what if this became the top of a mushroom? Inspired by the form, she decides to continue building in this direction, shaping her experiment into a mushroom key chain.*

3.3 Refining the Structure with Automated Pattern Organization

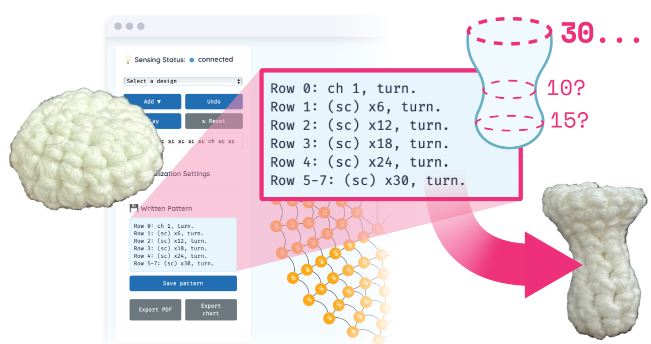

Figure 4: Anna reflects on her hat design, planning the continuation of her mushroom structure by referencing the technical details automatically recorded by the system.

Maintaining a clear structure in freeform crochet can be difficult, especially when pattern elements emerge spontaneously. Traditionally, documenting these structures requires crafters to declare each stitch manually, often in the exact order of execution, which can be unintuitive and laborious. While previous tools like Digital Crochet [33] have supported digital pattern drawing, they require the user to manually place each stitch individually on a canvas, interrupting the flow of creative work and making it difficult to keep the documentation synchronized with the evolving form.

StitchFlow addresses this by automatically organizing detected stitches into a coherent node-based representation. This visual structure not only reflects the logical relationships between stitches but also enables real-time feedback and forward planning. By visualizing the pattern as it unfolds, users can more easily spot inconsistencies, such as too many or too few stitches in a row, or identify missed steps. At the same time, the structured view allows them to consider the next steps in context, such as determining how many stitches are needed to continue from the current row. Rather than acting solely as a passive recorder of user actions, the system becomes a creative partner, supporting exploration while providing technical grounding.

Walk-through*: With the mushroom cap taking shape, Anna begins to examine the pattern more closely. The system structures her stitch data into a visual representation, revealing the slightly asymmetrical layout of her increases. Opening the written pattern view, she notices a mismatch between what she intended and what she actually made. The pattern indicates that she had made 11 stitches in the second row, making her realize she missed one stitch early on. Rather than undoing her work, Anna corrects the digital recording to reflect her intended pattern, ensuring that she, or anyone referencing the pattern later, will refer to the correct structuring. Curious about proportions, she uses the corrected stitch count to plan the diameter of the stem (Figure 4). As she continues crocheting, she glances at the live visual feedback and written cues to keep the shape aligned with her intentions, using the system both to reflect on what has been done and to sketch what comes next.*

By automatically generating an editable structure, StitchFlow relieves crafters from the burden of manual documentation at early stages. The system infers foundational relationships between stitches, providing an initial scaffold that users can refine, saving time while preserving creative momentum. The generated visual pattern mirrors the actual form in the maker's hands, offering a familiar reference point that blends technical accuracy with design intuition. This two-way exchange, where the system responds to the maker's improvisation and in turn helps guide future decisions and supports a more fluid and exploratory creative process.

3.4 Creating a Comprehensive Crochet Pattern

Crochet is a craft deeply rooted in sharing—whether through tutorials, patterns, or community forums. Yet translating a design from yarn to sharable instructions can be burdensome. Crafters often rely on a mix of representations: diagrams for structural clarity, written patterns for step-by-step guidance, and notes or annotations for personal context. Manually switching between these formats—especially after an improvised design process—can be time-consuming and difficult.

StitchFlow addresses this pain point by generating a comprehensive and editable documentation package that allows flexible visual generation. After capturing and organizing the crochet stitch inputs, the system generates three notations of the data: a node-based graph for visual layout, a standardized crochet chart for structural logic, and a written pattern for linear instruction. This is useful especially in an improvised design piece where the makers don't know which notation would be useful for their thought process and their audience until later in the design process.

Walk-through*: With her mushroom key chain complete, Anna saves the patterns in her pattern library (Figure 5.a) and starts to create a documentation for others to follow. She drags her mushroom hat and body patterns onto the canvas (Figure 5.b). The system presents her with multiple views of her work. She selects a combination of the node-based diagram and the written pattern, making it easier for both visual learners and beginners to follow her design. She appreciates not having to translate her work manually—the system has already organized her stitches based on how she crocheted them.*

Beyond auto-generated structure, StitchFlow invites personal input. Users can edit and annotate each view, add material references, insert process photos, or explain variations. This flexibility transforms the pattern from a mere set of instructions into a storytelling medium—capturing not just what was made, but how and why.

Walk-through*: Anna personalizes the documentation with a few important details. She notes the yarn color and adds a photo of the finished key chain (Figure 5.c). She tweaks the written pattern to clarify a method for increasing stitches shaping the stem and includes a picture of her embroidered white dots with a short note suggesting it as an optional detail.*

By easing the translation between different ways of thinking and documenting, StitchFlow supports not only individual creativity but also the collective culture of sharing and learning that defines the crochet community.

Walk-through*: With the pattern complete, Anna connects the diagram into a logical stitch flow (Figure 5.d) and exports the pattern into a PDF file format (Figure 5.e). Thanks to the system's structured organization and her custom additions, her design is now easily shareable. Others in the community can follow, refine, or adapt it to their own ideas.*

3.5 Summary

StitchFlow reimagines the crochet pattern creation process by unifying hands-on making with real-time, structured documentation. Instead of treating design and documentation as separate steps, the system captures stitch data as the user crochets, automatically organizing it into meaningful pattern structures. Through its multi-format representations—graph diagrams, standard charts, and written instructions—StitchFlow supports diverse thinking styles and

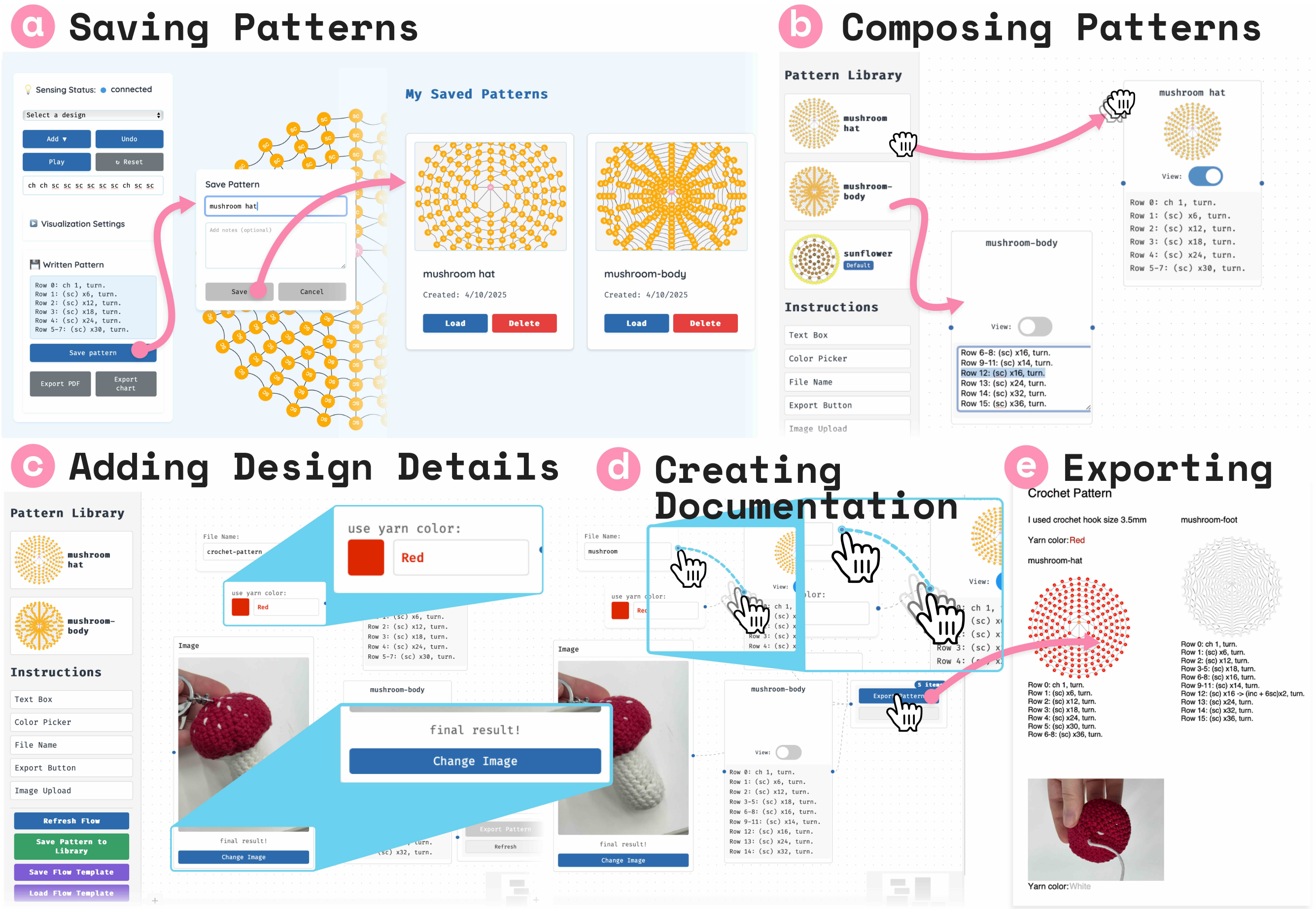

Figure 5: After completing the design process, the user utilizes StitchFlow to finalize and export the documentation of their crochet pattern.

documentation needs while reducing the manual overhead traditionally involved.

Throughout the process, users maintain creative agency: they can edit, refine, and annotate the auto-generated pattern, making it not just technically accurate but also personally meaningful. This balance between automation and customization enables crafters like Anna to stay immersed in their creative flow, while still producing patterns that are clear, comprehensive, and easy to share.

By making the process of designing, documenting, and sharing patterns more intuitive and integrated, StitchFlow empowers individual creators and strengthens the collective knowledge-sharing practices of the crochet community.

4 Implementation

Our system integrates real-time sensing, automated pattern generation, and an interactive interface for documentation. This section details the technical implementation of each component.

4.1 Sensing and Stitch Recognition

This section describes the implementation of the sensing system for capturing crochet gestures, the stitch classification model, and the characteristics of the collected dataset. It includes details of the hardware setup, data transmission, feature engineering, and classifier design.

Sensing System. The sensing system consists of an IMU sensor embedded in the crochet hook and a foot switch for explicit segmentation of stitch data. Foot switch is used to toggle the data recording through press and hold interaction. The IMU captures real-time motion data of yaw, pitch, and roll, while the foot pedal serves as a trigger and ensures that intentional crochet movements are recorded. Sensor data is transmitted from the embedded device to a Python-based processing pipeline via serial communication. The motion traces are preprocessed to extract features such as velocity and acceleration, which help to characterize the dynamics of different stitch gestures. A lightweight random forest classifier [4] is trained on a dataset of 780 labeled examples collected from multiple users. The system outputs real-time stitch predictions that are forwarded to the pattern visualization interface for live documentation and editing.

Model Evaluation. We trained the classifier on a dataset of 780 labeled samples comprising 300 samples from an experienced researcher and 60 samples each from 8 different participants, totaling 780 samples equally distributed among stitches. The model was tested on randomly sampled 20% of the dataset. The model achieved a strong overall F1-score of 91%, with per-class F1-scores of: chain – 99%, single crochet – 85%, and double crochet – 89%. The confusion matrix in Table 1 shows the errors occurred between the neighboring complexity stitches, such as single and double crochet. As a point of comparison, Cro-Create [5] attempted to recognize crochet activity using gesture recognition but was unable to classify complete stitches. Instead, it only detected individual movements that compose a stitch and did not report any quantitative accuracy.

True / Predicted	Chain	Single Crochet	Double Crochet
Chain	54	1	0
Single Crochet	0	39	10
Double Crochet	0	3	49

Table 1: Confusion matrix showing classifier predictions. Rows represent ground truth labels, columns represent predicted labels.

To improve robustness across users, we tested a light personalized calibration approach: augmenting a participant's training set with a small number of their own samples in addition to the researcher's baseline data. This increased the average classification accuracy to 94.9% (range: 89-99%, SD: 3%). The personalized model performed better than generalized one, due to varying characteristics of movement features among participants (refer to the appendix for dataset description).

4.2 Pattern Generation Algorithm

After stitches are classified, they are sent via WebSocket to a JavaScript-based parser that generates a structured representation of the pattern. Each stitch is treated as a node in a graph, with inferred connections based on common crochet conventions. Since the sensing system does not capture physical yarn connections, the algorithm infers likely placements and adjacencies, following standardized stitch behavior.

The input is a linear sequence of stitch types (Figure 6.a)—chain ("ch"), single crochet ("sc"), and double crochet ("dc")—and the algorithm distinguishes between row-based and round-based patterns. In both cases, the sequence is first tokenized by identifying "turning chains": a single "ch" between groups of stitches indicates a transition to the next row (Figure 6.b). For the foundation row (row 0), made entirely of chains, the final "ch" is treated as the turning chain.

Next, the tokenized rows are translated into a spatial layout that mimics the crochet structure. Rows are alternately read right-to-left and left-to-right, as is standard in crochet (Figure 6.cd). Each node is then positioned accordingly, and graph edges are added to reflect stitch relationships: horizontal edges connect adjacent stitches in the same row, while vertical edges represent structural dependencies between rows (Figure 6.e). Chains used for vertical spacing are not vertically connected to underlying stitches, and turning chains are visualized with directional arrows between rows.

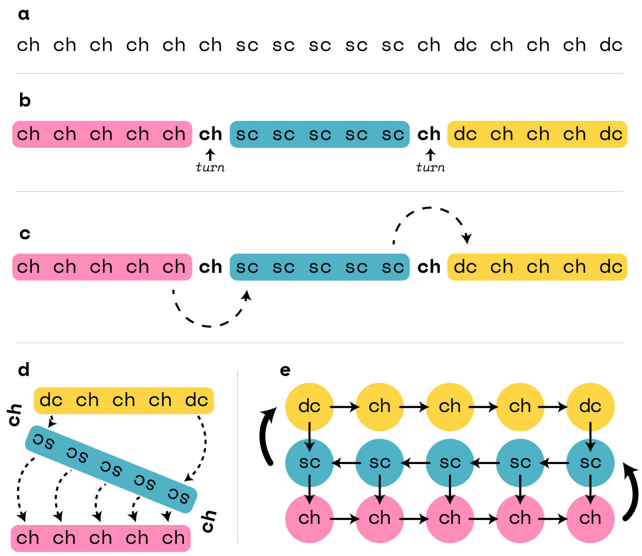

Figure 6: Pattern generation across formats: (a) begins with a sequence of recognized stitches, (b) stitches are tokenized into rows segmented by turning chains, and (c–d) translated vertically to represent physical form. (e) The structure is completed by inferring vertical and horizontal stitch connections.

4.3 Interface: Visualization and Project Composition System

The interface provides a visual representation of the generated crochet pattern and allows users to edit and compose their work. It is implemented as a web-based graphical application using the Svelte framework.

Key features of the interface include real-time visualization, manual adjustments, and a project composition canvas.

4.3.1 Real-time Visualization. Detected stitches and inferred pattern structures are displayed as a graph, where nodes represent stitches and edges indicate connections. Users can toggle between row-based and round-based views and between node-based and traditional chart-like crochet diagrams depending on the nature of their project.

A written version of the pattern is also generated in real-time. Each row or round is summarized, and repeated stitches or sequences are automatically condensed into standard crochet notation (e.g., "ch x3, (sc, dc) x5").

4.3.2 Manual Adjustments. Because automatic pattern generation may include inaccuracies due to sensing limitations or variations in crochet execution, the interface allows users to manually edit stitch types, counts, and sequences. This ensures the final pattern reflects the user's intended structure.

Users can also modify the appearance of the node-based chart, such as adjusting node sizes or applying colors to convey additional information (e.g., stitch difficulty, materials used).

4.3.3 Project Composition and Exporting. The interface supports exporting the pattern in multiple formats: graphical representations (node graph or chart) and written instructions in PDF format.

In addition, the system includes a project composition canvas, where users can organize through a modular, flow-based interface. On this canvas, various node types can be placed and connected via edges, forming an information flow that documents not only the structure of the pattern but also its story.

Node types include:

- **Pattern nodes:** Generated through real-time sensing; provide access to all three pattern representations (node graph, chart, written).
- **Text, image, and color nodes:** Used to annotate or enhance the pattern with contextual information or design notes.
- **File name and export node:** Enables file naming and aggregates connected nodes and outputs a compiled PDF document containing the complete pattern and supporting materials.

Edges between nodes define the intended sequence or logical relationships between different elements of the project. This flow-based structure supports the documentation of not only the final pattern output but also the rationale and process behind it. Users can include design variations, describe specific techniques, or provide instructional breakdowns of complex pattern sections, enabling a more comprehensive representation of the crochet project.

5 User study

To evaluate the effectiveness of StitchFlow in supporting in-situ creativity, we conducted a qualitative expert study with experienced crocheters. The goal of the study was to understand how practitioners integrate digital patterning tools into their existing workflows, what types of documentation or editing actions they perform, and whether real-time support can reduce the effort of pattern recording.

The study followed a flexible, exploratory format using think-aloud protocols and semi-structured interviews. This approach enabled us to observe participants' natural interactions with the system while also capturing their reflections on creative decision-making, system usability, and the role of StitchFlow in their broader crafting practice.

5.1 Study Procedure

Each session was structured into three phases: System Introduction, Crocheting with StitchFlow, and Post-Study Interview.

In the first phase, participants were introduced to StitchFlow and its core features, including real-time stitch detection, pattern correction, visualization, and project composition tools. A brief tutorial was provided to familiarize participants with the interface and key functionalities.

In the main task, participants were asked to crochet and document a self-chosen design (e.g., a coaster) using the StitchFlow. They were encouraged to think aloud, freely transition between crocheting and editing, and seek assistance regarding system usage to ensure that they could best express their design. Participants iterated until they were satisfied with the final pattern output.

After the task, participants took part in semi-structured interviews focused on their experience using the system, its impact on workflow and creativity, impressions on real-time documentation, and any challenges encountered.

5.2 Material and Method

We recruited 8 participants based on two main criteria: prior experience with crochet and familiarity with documenting their own patterns using written instructions, charts, or freehand notes. All participants were female, aged 18–24 (M = 22, SD = 2.3), and reported high confidence in performing chain, single crochet, and double crochet stitches. Each participant also demonstrated high familiarity with at least one of the following: written patterns, chart patterns, freehand crochet, or original pattern creation. Participants were compensated the equivalent of 20 USD in local currency.

Data was collected through system logs tracking interactions with the interface, such as manual changes in input stitch sequence and modification of display settings. The procedure was recorded through camera and screen recording, observation notes, and transcripts of semi-structured interview for qualitative analysis. Lastly, we collected scores from participants for the System Usability Scale[22].

The collected data was analyzed qualitatively to identify recurring usability patterns, documentation strategies, and how the integration of real-time tools affected participants' design process.

5.3 Results

All participants completed the design task in under one hour, with an average time of 44 minutes (SD = 10 min, Range = 24–55 min), the majority of which was used to record patterns (M = 40 min, SD = 11 min), and the rest (M = 3.5 min, Range = 1-6 min) for composing their final patterns. The overall usability of StitchFlow, as assessed by the System Usability Scale (SUS), was rated at an average score of 79.7 out of 100 (SD = 11.8), suggesting a generally positive evaluation of the system's ease of use.

Figure 7 shows eight crochet structures produced by participants, reflecting a variety of creative approaches. These included three-dimensional forms such as a pottery-like structure (P1), functional items like coasters (P5, P7), and abstract or decorative pieces (P0, P6). Participants demonstrated two design orientations. Some approached the task as an evolving process, letting their design unfold as they crocheted. An example of this can be seen in P0, P1, P5, and P6, where they engaged with the task in an exploratory way, making decisions in the moment and adapting their design as they progressed, either spontaneously or by recalling inspirations. Others were more visually driven, beginning with a clearer idea of the end result through colors and shapes. This was evident in participants like P2, P3, and P7, who worked toward visual outcomes, such as a flower with a stem (P2) or an asymmetric form (P7). Both modes reflect creative engagement, although grounded in different sources:

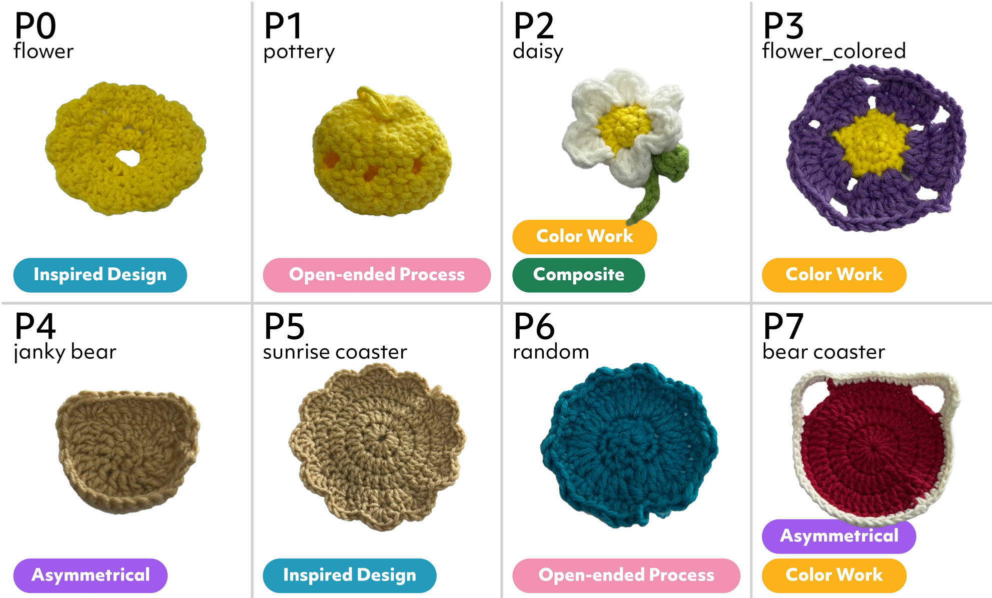

Figure 7: Objects created by study participants, grouped by variations in their design processes.

Participant	Stitches Recorded	Stitches in Pattern	Undo Stitch	Add Stitch	Text Edits	Frogged Stitches
P0	127	117	13	8	1	3
P1	163	166	3	4	25	15
P2	94	88	1	0	17	3
P3	110	105	0	0	5	0
P4	70	75	0	0	5	0
P5	194	197	5	9	7	0
P6	87	107	2	0	8	25
P7	228	225	17	10	6	5
Avg	134.1	135.0	5.1	3.9	5.9	6.4
SD	52.2	54.4	6.4	4.5	7.8	9.0

Table 2: Participant interaction summary during the user study.

one stems from tactile exploration and emergent decision-making, the other from visual imagination and premeditated form.

Varying degrees of color and structural complexity can be seen in the outcomes. Some participants (P2, P3, P7) incorporated multiple colors. P2, for example, constructed a two-part design and sewed the flower and stem together. Simpler projects included between 74 and 95 stitches (P2, P4, P6), while more complex outcomes included up to 225 stitches (P7). Most participants used a combination of chain, single crochet, and double crochet stitches. Notably, P5 relied predominantly on double crochets (91%), while P2 incorporated half-double crochets—stitches not predefined in the system's sensing categories but still used during creation.

The annotated timeline of each session (Figure 8) was categorized into four interaction types: *Design* (thinking/planning aloud), *Crochet* (physical making), *Editing Tool* (interface use for tracking, modifying or checking progress), and *Composing Tool* (final documentation step). This timeline visualization reveals diverse workflows and interaction patterns across participants.

Participants P0–P2 switched frequently between crocheting and using the interface in the early phase of their sessions, suggesting both a learning curve and an exploratory process of familiarizing themselves with the tool's functions. P3, P4, P6, and P7 adopted a different pattern, working on larger segments of their projects before dedicating extended periods to reviewing and reflecting on their work in the editing tool.

The timeline also captures moments of creative flow disruption and recovery. For instance, when P7's yarn ball rolled away, this triggered a pause followed by a re-engagement with the editing tool—demonstrating how the interface helped participants regain focus by displaying their recent activity and overall progress.

Documentation behaviors varied as well, with P0 and P4 incorporating photos of their crochet pieces into their final documentation.

Design iteration through "frogging" (unraveling and redoing parts of their work) was observed in P0, P1, and P2, highlighting how StitchFlow accommodates traditional physical-craft revision practices.

Because the study was designed to support open-ended, uninterrupted creative exploration, we did not collect real-time ground-truth labels of stitch types during use. Introducing such labeling would contradict the in-situ and creative exploration goals of our study. As a result, direct measures of detection accuracy during the study are unavailable. Instead, to understand how the system was used in practice, we analyzed participant interaction logs presented in Table 2. Participants recorded between 70 and 228 stitches (M = 134.1, SD = 52.2), with their final patterns containing 75 to 225 stitches (M = 135, SD = 54.4). Correction tool usage varied across individuals: the “undo stitch” feature was used between 0 and 17 times (M = 5.1, SD = 6.4), while the “add stitch” tool was used 0–10 times (M = 3.9, SD = 4.5). Participants also made between 1 and 25 direct text edits (M = 5.9, SD = 7.8), and physically undid an average of 6.4 stitches through frogging (range: 0-25, SD = 9). These behaviors highlight participants' active engagement in shaping their outcomes and their use of the tool for both correcting detection errors and iterating on design ideas.

The System Usability Scale item-level responses suggest general ease of use and positive user experience. Participants agreed that the system was easy to learn (M = 4.5, SD = 0.5), easy to use (M = 4.25, SD = 0.66), and that the functions were well integrated (M = 4.125, SD = 0.78). They also indicated a willingness to use the system frequently (M = 4.25, SD = 0.83). Lower scores on reverse-coded items, such as inconsistency (M = 1.375, SD = 0.48) and needing to learn a lot before use (M = 1.5, SD = 1), further support these positive assessments.

5.4 Interview Results

Our study with 8 participants demonstrates that StitchFlow effectively supports in-situ exploration and iteration in crochet pattern creation. Functioning as a creativity support tool, it facilitates ongoing interaction, experimentation, and sharing. The findings reveal several key insights about how digital pattern recording can be seamlessly integrated into the creative process.

5.4.1 Support for In-Situ Exploration. StitchFlow reduced the burden traditionally associated with pattern documentation, allowing users to maintain their creative flow without interruptions (P0, P4). As P0 noted, the system "handled technical aspects, while she focused on the creative". This shift from technical documentation to creative exploration represents a significant improvement in the creative flow, with P0 explaining that it "helped her focus on what she wants to make rather than thinking how to make it".

The real-time nature of the tool encouraged experimentation. For instance, P2 compared the experience to piano playing: "If I play something new, it is hard to remember and record the notes". By automating documentation, the system created space for creative exploration that would otherwise be constrained by the cognitive load of manual recording.

P1 and P6 exemplified the system's support for open-ended, exploratory making. P1 created a three-dimensional ball with “windows” on the side and called it “pottery,” while P6 made a round structure with a ruffle on the edge and simply labeled it “random” (see Figure 9.a). Both participants emphasized that they were unsure what they were making during the process or even after completing it, aligning with the goal of improvisational and flow-based support for creative practices.

5.4.2 Facilitation of Iteration. The system's real-time recording capabilities supported iterative design and planning. P1 described it as particularly helpful for forward planning: "The number of stitches in the last row helps to plan the next row". Similarly, P4 observed that the "end of a row is a natural stop point [that] allows [her] to reassess," highlighting how the system aligns with the maker's natural workflow and decision points.

Participants adopted different strategies for correcting errors, whether made by themselves or by the system. For example, P1 initially intended to fix mistakes immediately but later chose to make corrections row-by-row, while P4 preferred to “notice the mistakes, but fix it later.”

Customization also played a key role. P0 used color to differentiate stitch types in the visualization, and P3 modified the written pattern's text to better match her personal notation style. P4 adapted the system's structured pattern to accommodate her asymmetrical bear-ear design.

P3 further demonstrated how the system supports pattern iteration and remixing. After recording her pattern named "flower", she reloaded it and added color annotations to represent the yarns used, shown in Figure 9.b. This allowed her to create two versions of the same pattern: one structural, and one reflecting material choices. Such use highlights how digital patterns can serve as editable templates for future creative reinterpretations.

5.4.3 Creativity Support Through Visualization and Organization. Another aspect noted by participants during the study was StitchFlow's support from immediate visual feedback. For example, P0 opted for a row-based view, even when working on a circular design, because it allowed her to see the unfolded version of the pattern.

Participants saw the system as both a creative tool and an organizational aid. P5 described it as a potential “library of [her] own projects and experience,” while P6 envisioned dual use cases: for recording spontaneous making during highly creative sessions, and for structured planning during deliberate design. This versatility supports diverse workflows across different levels of intention and expertise. P2 exemplified this versatility by creating a multi-piece project consisting of both a flower and a stem, recorded as separate but connected pieces (see Figure 9c). This use case demonstrates how StitchFlow can accommodate not only linear design but also larger, composite creative visions. P3, who had experience designing for a local crafting community, valued the system's ability to automatically generate multiple pattern formats, noting that it “creates all types of pattern types,” removing the need for manual conversion. This capability not only saves time but also opens up new design possibilities and broadens accessibility for different audiences.

5.4.4 Fostering Further Interactions and Sharing. The system enabled participants to quickly generate finalized pattern documents. As previously noted, participants spent the majority of their time crocheting and recording their designs, with only a few minutes

Figure 8: Annotated timeline of each participant's main task execution. Annotations include quotes, contextual descriptions, screen captures, and observations illustrating how participants engaged in creative design, crocheting, tool-based editing, and documentation composition.

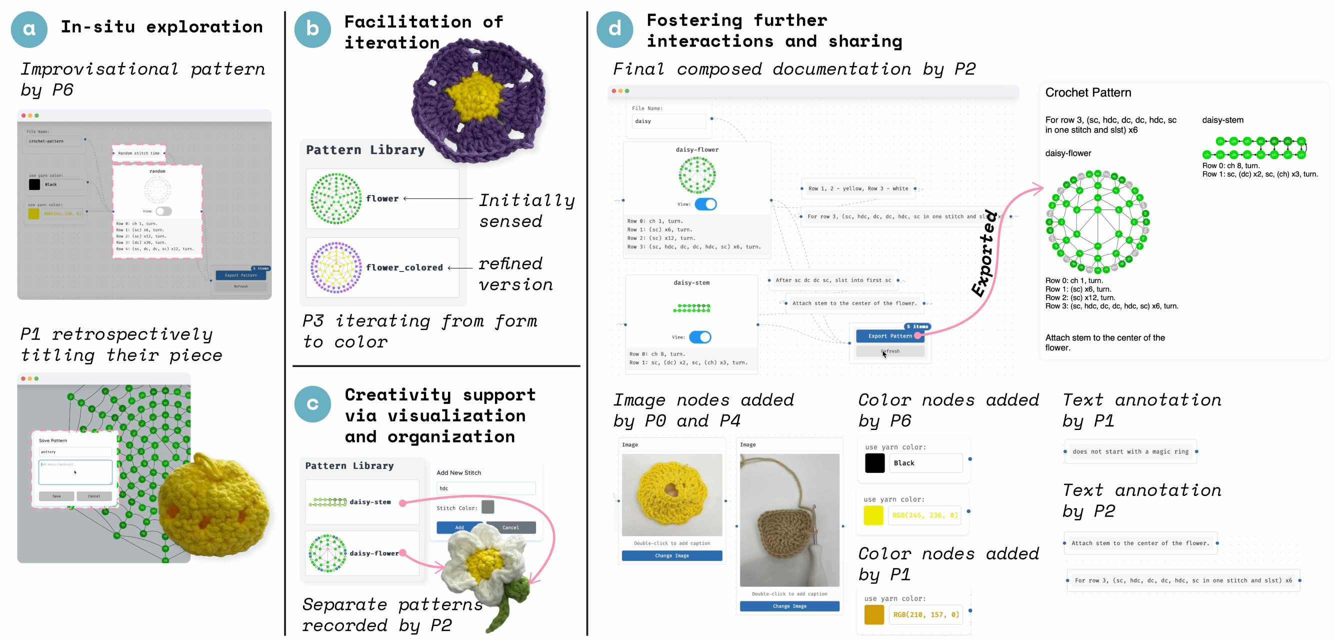

Figure 9: Participant use cases of StitchFlow in supporting: (a) in-situ exploration, (b) iterative making, (c) visualization and organization, and (d) interactive composition and pattern sharing.

(M = 8.5% of the whole task time) needed to compose the final pattern. This ease of finalization lowers the barrier to sharing and re-purposing patterns.

StitchFlow was perceived as suitable for supporting more complex projects. For example, P1 noted its potential usefulness for multi-part designs, such as sweaters composed of several panels, and explained that it "would be much easier to see the pattern [in one place]" using the system. P7 similarly commented that while simple patterns like coasters are easy to remember, "it would be more accurate to use for big-scale projects."

The system bridges individual making and community sharing by capturing and translating personal crochet techniques. P5 called it a "translator for oneself" when adapting patterns found online, reflecting how individual interpretations often differ from conventional pattern representations.

All participants used the tool to annotate their patterns with specific instructions for others. P2 added text descriptions for sewing steps and color guidance, while P4 edited the written pattern to clarify how to form the bear ears in her design. The final composition made by P2 with multiple patterns and annotations and its corresponding pattern file can be seen in Figure 9.d. Figure 9.d also includes examples of informative nodes added by other participants: image (P0, P4), color (P1, P6), and text (P1, P2). These additions suggest that StitchFlow facilitates the transformation from individual making processes into shareable instructions for broader audiences.

5.4.5 System Limitations and User Feedback. Despite the overall positive reception in terms of StitchFlow support for in-situ creativity, participants identified several limitations that affected their experience. Multiple participants (P1-4) expressed a desire for the system to support more stitch types beyond the current implementation. P1 suggested that the system could let the user train it to detect their own stitch definitions. The addition of spatial features was another requested improvement mentioned by P6 and P7, who wanted better ways to represent the three-dimensional aspects of their designs. Several participants also noted they would appreciate more freedom in editing their patterns beyond the current features of StitchFlow. The foot switch interaction mechanism yielded varied responses based on individual crocheting styles. Some participants found that their crochet motions were more blended together, which initially made using the foot switch feel awkward, though they expressed that they were able to adapt over time. Other participants reported having more distinctive motions for each stitch and consequently had no difficulty using the foot switch to mark their stitches.

6 Discussion

Our findings reveal important insights into how digital tools can support the creative process in traditional crafts like crochet. Here, we discuss the implications of our results, the limitations of our study, and directions for future work.

6.1 Balancing Automation with Creative Control

The tension between automation and creative control emerged as a central theme in our study. While participants valued the documentation that freed them from manual recording (P0, P1, P7), they also expressed a desire for more control over certain aspects of the system. P2 stated a preference for "more flexibility in the interface rather than having an accurate system," highlighting that crafters view technology as a supportive companion rather than a substitute for creative judgment.

This balance is crucial for creativity support tools in traditional crafts, where practitioners value both efficiency and personal expression. Eglash et al. [12] discuss the potential of human-machine collaboration to enhance the economic and environmental sustainability of crafting professions, emphasizing that automation technologies should empower artisans without diminishing their creative agency. StitchFlow does so by sensing and visualizing stitches in real time, creating a feedback loop where the outcome is reflected in the tool, while the tool influences the outcome. Future iterations of StitchFlow could introduce customization of automation levels, enabling users to decide which aspects of pattern documentation to control manually and which to automate, thereby supporting both efficiency and personal expression.

6.2 Cognitive Flow and Creative Interruptions

Maintaining cognitive flow is crucial in creative practices [9]. Technology can be designed to align with the natural rhythms of craft activities [6, 26]. P0 noted that the system eliminated interruptions that "disrupt creative process", while P4 observed that "the end of a row is a natural stop point, and allows to reassess". Our findings resonate with this, as participants appreciated that StitchFlow reduced the need for manual documentation, allowing editions during natural pauses in their workflow. Designing systems that respect and integrate into the inherent flow of crafting can enhance user experience and support sustained creative engagement.

6.3 From Personal Creation to Community Sharing

Digital platforms have transformed the landscape of craft communities, facilitating virtual communal sharing [20, 41]. However, sharing in these communities often requires the creation of well-formatted patterns, a process that can be time-consuming and burdensome, especially for those less experienced in documentation or formatting conventions. StitchFlow addresses this challenge by automating the generation of multiple pattern formats and composing tools for the documentation and personalization of patterns.

A notable finding was how StitchFlow facilitated the transition from personal creation to shareable content. Participants like P3, who had previously created patterns for community use, appreciated the automatic generation of multiple pattern formats, lowering an entry barrier for her to create new patterns as she is more proficient in written pattern formatting. P5's description of the system as a "translator for oneself" suggests that tools like StitchFlow can bridge personal and communal creative practices.

StitchFlow's ability to generate patterns in multiple formats with personal input can lower barriers to participation, enabling crafters to contribute to the community's pattern library, and fostering a more inclusive and collaborative environment.

6.4 System Limitations and Further Directions

Participants identified several limitations of the current system. Physical concerns included the weight of the instrumented hook (P5) and the coordination requirement for using the foot pedal (P6). On the software side, participants desired support for more stitch types (P1), custom stitch definitions (P1, P7), and additional metadata such as yarn weight and hook size (P5, P7).

Participants suggested new directions, including voice control for pattern editing as suggested by P4 "being able to talk to it would be better than editing", integrating recognition from image (P7), and gesture-based controls for indicating self-defined actions (P4). Additionally, participants suggested features that would extend the system beyond pattern organization into pattern following (P6, P7) and pattern remixing (P5, P7) indicating the potential for more comprehensive crafting support.

Our study focused on experienced crocheters familiar with process documentation, which provided valuable insights but may not represent the full spectrum of crocheting experiences. Future studies should include beginners to understand how such tools might support learning, as well as professional designers to explore more complex usage scenarios.

The limited duration of the study also meant that participants created relatively simple projects. Understanding how StitchFlow fits into different levels of expertise and long-term practices will be crucial to understanding its potential as a creativity support tool embedded within the evolving ecosystem of craft.

Lastly, this work focused on developing a system that passively supports crochet pattern documentation during the act of making. Given this scope, there remain many opportunities for future exploration, including more granular sensing of nuanced crochet gestures beyond stitch execution, as well as interactive features such as active guidance, pattern suggestions, or adaptive feedback.

StitchFlow represents a step toward responsive technologies that enhance, rather than replace, traditional crafting practices. Through the design and evaluation of a real-time crochet documentation system, our study contributes new insights into how digital tools can support creativity, preserve embodied making, and foster the transition from personal creation to community sharing.

We found that effective craft-support systems should align with the natural rhythm of creative practice, offer flexible levels of automation, and remain sensitive to the preferences of artisans. These principles extend beyond crochet, offering implications for the design of interactive systems across a variety of traditional crafts facing similar challenges in documentation and dissemination.

More broadly, this work contributes to a growing conversation in HCI about respectful and generative relationships between human skill and machine intelligence. As craft continues to evolve in dialogue with technology, StitchFlow demonstrates the potential for tools that support creative agency, expanding how we create, document, and share in the digital age.

Acknowledgments

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A Dataset Features

We provide the definition of features used as well as a average values for each of the features between participants in the dataset.

- **Duration** The total time taken to complete a stitch sequence, measured in milliseconds. Calculated as the number of frames in the sequence divided by the sampling rate (119 Hz).
- **Direction Changes (Yaw, Pitch, Roll)** The number of times the direction of movement changes (zero-crossings) in the yaw, pitch, or roll signal. This reflects how often the movement reverses.
- **Complexity (Yaw, Pitch, Roll)** The number of acceleration peaks in the second derivative (acceleration) of yaw, pitch, or roll. This measures the number of rapid changes in movement.

Feature	P0	P1	P2	P3	P4	P5	P6	P7
duration (ms)	2718	1257	1032	1141	560	849	1254	513
yaw_dir_change	15.05	7.55	4.6	6.3	3.15	4.05	6.55	2.55
pitch_dir_change	18.9	6.2	5.1	6.6	3.85	5.25	7.6	3.2
roll_dir_change	15.1	9.95	5.95	6.65	5.6	5.95	4.05	3.45
yaw_complexity	9.35	4.65	3.5	3.45	2.05	2.8	3.55	2.0
pitch_complexity	9.3	4.15	2.85	3.4	1.75	2.6	4.05	1.65
roll_complexity	9.6	4.2	3.4	4.4	1.7	2.7	4.5	1.9

Table 3: Feature summary for chain (ch) stitch. Duration is given in milliseconds, while all other values are unit values.

Feature	P0	P1	P2	P3	P4	P5	P6	P7
duration (ms)	9662	2743	2615	3026	3341	4628	2768	3435
yaw_dir_change	59.9	14.5	13.25	9.9	16.55	26.8	12.1	22.8
pitch_dir_change	69.2	13.5	12.1	12.7	14.2	37.6	9.6	23.05
roll_dir_change	62.75	23.7	12.5	16.9	26.15	28.95	17.1	26.2
yaw_complexity	31.0	9.5	8.4	9.4	10.65	15.0	8.75	11.0
pitch_complexity	31.5	6.95	8.15	9.65	11.45	14.9	8.5	10.95
roll_complexity	32.85	10.8	8.5	9.3	10.2	14.5	8.95	12.05

Table 4: Feature summary for single crochet (sc) stitch. Duration is given in milliseconds, while all other values are unit values.

Feature	P0	P1	P2	P3	P4	P5	P6	P7
duration (ms)	12138	4546	4526	5657	4286	6889	5091	5368
yaw_dir_change	78.1	23.2	22.6	28.2	16.55	26.9	27.8	27.45
pitch_dir_change	87.65	22.95	21.1	26.25	10.15	25.15	26.9	21.95
roll_dir_change	80.3	32.35	23.7	28.6	15.55	36.0	29.15	27.35
yaw_complexity	38.75	14.8	15.6	16.65	13.95	22.55	17.5	17.05
pitch_complexity	39.5	12.8	14.35	17.3	14.25	21.75	14.85	17.0
roll_complexity	38.0	15.2	14.7	18.25	13.55	23.4	15.8	18.25

Table 5: Feature summary for double crochet (dc) stitch. Duration is given in milliseconds, while all other values are unit values.