Cro-Create: Weaving Sound Using Crochet Gestures

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ABSTRACT

Cro-Create is a crochet gesture recognition sonifier for individual and collaborative use. In single user mode, Cro-Create directly scales and maps numerical palm orientation values detected by a motion sensor to sound. In dual user mode, the system affords users with additional auditory feedback by detecting when two users' gestures are synchronized by segmenting the gestural procedure of making a stitch in crochet into three stages and utilizing a dynamic time warping algorithm to classify and recognize these stages; when the system determines that both users have produced the same gesture, the sonification is complemented by a distinguishable chord. Through this demonstration we introduce our tool to share procedural state for the physical craftmaking process, crochet, through sound.

CCS CONCEPTS

• **Human-centered computing** → **Collaborative and social computing devices**; **Collaborative interaction**; *Auditory feedback*; *Gestural input*.

KEYWORDS

motion detection, tangible user interface, textiles, sonification

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1 INTRODUCTION

Crochet is a relaxing craftmaking activity that has shown many benefits in the past such as stress management [2, 4]. Previous researchers have explored ways to enhance similar crafting activities, such as knitting and weaving, through sonification [3, 6]. The benefits of sonification have been explored in multiple contexts such as to improve performance in training for sports [10] and to make visual elements more accessible for the visually impaired [5, 8]. In [6] the authors note how sonification made knitting a much more engaging experience and encouraged participants to experiment with their technique. In this study, we create a gesture recognition system to detect various common gestures made whilst crocheting and use the detected gestures to generate auditory feedback.

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1.1 Crochet

In this work, we decompose hand gestures used in the fiber art, crochet. The practice of crochet requires only one hook and a ball of yarn. The fundamental unit of progress in crochet is the stitch. There are a series of foundational stitches in crochet that can be built upon each other to create intricate patterns or add structure to a crafted object. Figure 1 shows some examples of crocheted items created by following and modifying existing patterns. In addition to the foundational stitches' use in building greater components when intertwined, they are also extensions of one another in terms of how they are constructed. For example, a single crochet and a double crochet are both commonly seen as foundational stitches, but the routine to produce the single crochet is embedded in the routine to produce the double crochet. All stitches in crochet are created by using a hook to twist, pull, and push the yarn from the front to the back of the worked piece. In this demonstration, we sonify and classify two hand motions used to create a stitch.

1.2 Motivating Principles

The most effective method for collaboration depends on the medium of communication and the content of the messages users wish to convey. In crochet, where the non-expert creators must keep an eye on their work to determine where next to position their hook, sharing visually descriptive information about one's practice to others nearby becomes more challenging [12]. In some cases experts can manage to take their eyes off their work due to a developed muscle memory of the routines, but this places a greater reliance on tactile feedback and the creator's memory. While many crocheters find community in the hobby and enjoy practicing it in a social setting, the activity often necessitates their visual attention [9]. Though crochet has been shown to cement and forge interpersonal relationships, it is an individual activity that requires a non-trivial degree of concentration [11]. In this demonstration we enable users to convey the synchronicity of their gestures through an auditory medium.

2 GESTURE RECOGNITION

2.1 Design Iteration

Because more advanced crochet stitches are extensions of simpler stitches, determining how to segment the gestures found in crochet such that they could be recognized by a dynamic time warping (DTW) classification model necessitated multiple design iterations. Initially, we had thought to classify gestures by the foundational stitches discussed in section 1.1 and track the progress between two users against a crochet pattern dictating the order of stitches to produce. This idea was discarded when we recognized that the model could not distinguish stitches which had the procedure for

(a) Sweater vest

(b) Beckoning cat

Figure 1: The first author's crocheted creations made by following and modifying crochet patterns. A pattern denoting the number, order, and type of stitch to use allows the crocheter to reproduce the pattern designer's initial creation.

the simplest stitch (the single crochet) embedded in its own procedure. We decided to develop our model at a finer granularity of crochet progression by classifying gestures which are present in every stitch: instead of detecting progress in relation to the whole crochet pattern, we detect progress in relation to the development of individual stitches.

We had a considerable number of options provided by the Leap Motion Controller for how we would train our model. The accompanying software offers relative three-dimensional coordinates for position and orientation for each junction of the bones in the fingers, as well as the palms of the hands detected by the system [7]. Initially, we expected and trained our gesture recognition model using the position and orientation scalar values for the distal portion of each finger. Interestingly, training on this input hardly resulted in accurate gesture classification. Through a series of experiments with different input data, we considered which fingers, and specifically along which axes the fingers move, are primarily used in developing stitches in crochet. We came to the conclusion that, while some fingers may be more critical in crochet, people have different strategies for holding the tools and using their fingers. It was with this insight that we opted to use the palm orientation scalar values for each hand in the frame. Palm movement tended to leave less opportunity for variation in making a stitch. Not only did using the palm orientation data improve the accuracy of the classifier, but it also decreased the overhead of sending several input features to the model, thereby improving computational performance.

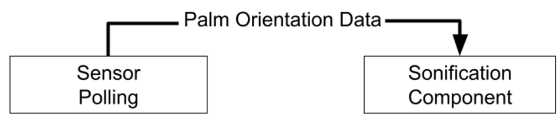


Figure 2: System architecture of single user mode

3 SINGLE USER MODE

Single user mode is composed of two entities, the sensor polling code and the sonification component. In this mode, the user's hand motions directly manipulate the sound by way of the palm orientation scalar values captured by the Leap Motion Controller. Sound is produced after sending one or more Open Sound Control (OSC) packets, containing two decimal numbers representing the palm orientation values of both hands for every frame captured by the motion sensor, to the sonification component [13]. These floating point values are sent to a MaxMSP patch that scales the values received to the notes on a 48-key keyboard [1]. The values representing the movements of the user's dominant hand control the pitch using the scaling mechanic, while the values representing the movements of the user's non-dominant hand control the duration of the note produced from the movements of the primary hand. Figure 2 shows the component-wise relationship in single user mode.

4 DUAL USER MODE

Dual user mode incorporates gesture recognition to convey synchronization audibly with the addition of two more components–the dynamic time warping model and the gesture comparator–extending the simple design of the single user mode. In dual user mode, two users each use a machine equipped with the Leap Motion Controller peripheral. On each machine, the sensor polling code is run and sent to the appropriate components depending on the role of the user. We distinguish two roles in the design and usage of dual user mode: leader and follower. The leader is called as such because the

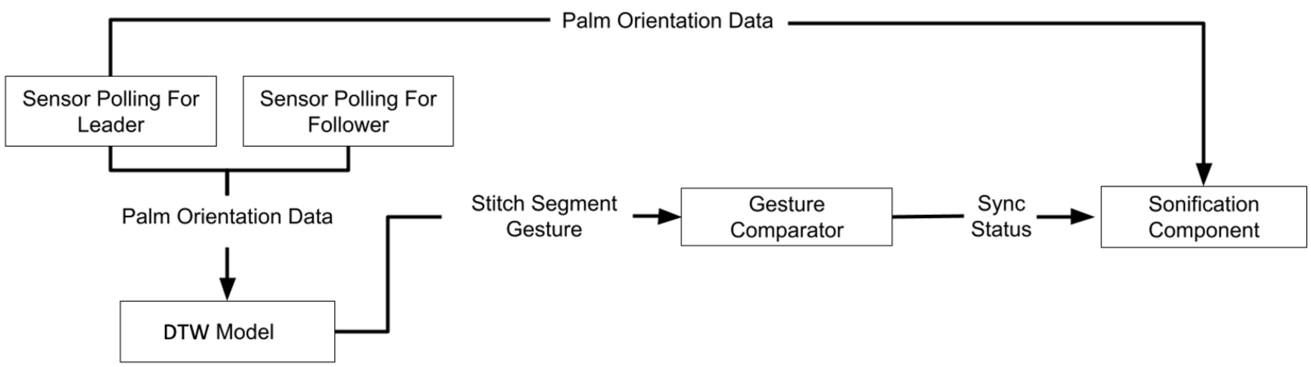
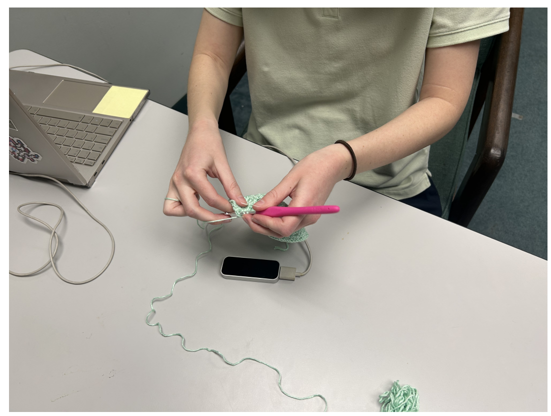


Figure 3: System architecture of dual user mode

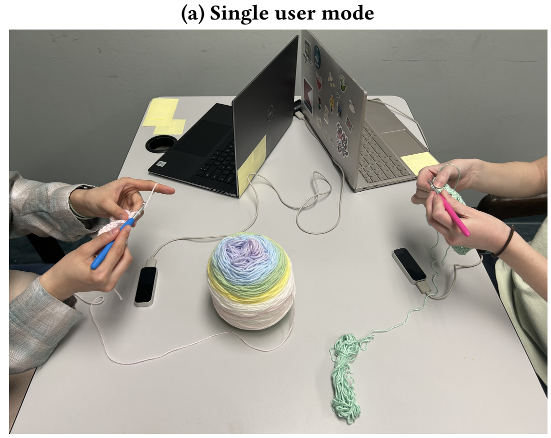
motions of this user drive the melody produced by the sonification component as is done in single user mode. The follower's current detected gesture is compared to the leader's last gesture to assess synchronicity. In this sense, dual user mode can be thought of as a first iteration of a tutorial system for collaborative crochet: one user takes a leading role while the other's motions are compared.

4.1 System Architecture

The system diagram can be seen in Figure 3. The palm orientation data from the leader is sent to both the model and the sonification component. This data immediately grounds the melody produced by the sonification component as is done in single user mode. When this data is sent to the model, it is used to classify one of three gestures. These gestures can be observed when a user produces a stitch in crochet: they are 1) stationary, 2) dip into stitch, and 3) pull through loop. Similarly, the palm orientation data from the follower is sent to another instance of the model running on the follower's machine. Right after each user's gesture is classified, an OSC message indicating which gesture was produced by a user is sent to the gesture comparator. In addition to the type of gesture produced, the OSC message also indicates which user made the gesture–either the leader or the follower. According to the synchronization logic outlined previously, the gesture comparator sends a binary value to the sonification component. This binary value indicates whether the leader and follower are synchronized, and serves as a signal to the sonification component to complement the harmony produced by the leader's palm orientation data by producing a chord an octave below the last note produced by the leader's palm orientation data when the two users are synchronized. We can hear the leader's gestures continuously, as well as when the two users are synchronized. Both single and dual user modes are depicted in Figures 4a and 4b, respectively.



(a) Single user mode



(b) Dual user mode

Figure 4: Interaction modes demonstrated

5 FUTURE WORK

Presently, we are running a participatory design study to understand how we can improve Cro-Create to support collaborative craftmaking through sound. Our study includes three participant groups that can lend different insights into how Cro-Create can be improved. Each group will partake in a series of activities over the course of a one to two hour session; these activities are aligned with the perspectives and experiences participants can provide us to improve the system. We divide participants into three groups:

1) non-crocheters (individuals who have had less than one year of experience crocheting), 2) crocheters (individuals who have more than one year of experience crocheting), and 3) experts (individuals who have several years of experience in topics relevant to the motivating principles and applied technologies used to build Cro-Create).

At the time of this writing, we have ran the session for the non-crocheter group. This session included informational activities on the Cro-Create system and sonification, followed by a crochet tutorial where participants learned three elementary crochet procedures (slip knot, chain, and double crochet), and ending with a focus group where participants engaged in discussions on their impressions of crochet and the experience they had learning the gestural procedures for the first time.

6 CONCLUSION

In this work we introduced Cro-Create as a tool to share the process of creating a crochet work through sound. We introduced the procedural nature of crochet which allowed us to segment crochet's fundamental unit of measure, the stitch, for classification by a dynamic time warping model. We shared our iterative design process, whereby we considered which and how many data points on the hands would most appropriately encapsulate the subtle gestures performed in crochet to build a more robust model. The technical interaction of the Cro-Create system's components is explained for both single and dual user modes. The use of the OSC protocol for communication between the two users' machines in dual user mode highlights the system's potential for supporting co-creation and the embodied interaction of craftmaking between users separated by wide distances. Finally, we shared our ongoing study to investigate how Cro-Create can be further developed and utilized.

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