Application of XML-based Language for Digital Representation of Crochet Symbols

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Abstract. This paper views the problems related to the development of crochet software. It presents an extension of PKF - XML-based language for digital representation of crochet patterns. Its purpose is to develop a uniform and platform independent description of simple graphic primitives corresponding to different types of stitches. Due to the crochet symbols' features the suggested format is particularly suitable for their description. Graphic primitives are described in vector format, character transformations are allowed, and there are possibilities for creating combinations of symbols, called clusters – major components in crochet diagram. The XML language can be built on crochet software.

Keywords: Crochet Software, Knitting Software, CAD Systems, XML, Home Crafts, Digitalization, Computer-aided Design.

1   Introduction

Traditional home crafts as crochet, knitting and embroidery are a part of cultural heritage of many countries. Given the fact that modern textile production is entirely machine-made, few people are engaging in these home crafts. Nowadays home-made textiles are practiced as a hobby, but sometimes they might be turn into a business (Adriprints Press), (Aran Sweater Market, 2017), (Axioma Hobby Shop, 2010). Regardless of whether crochet, knitting or embroidery is practiced as a hobby or as a small business, their practice keeps traditions alive. It is important that such traditional crafts are supported and this can be done through modern computer technologies (Abello, Broadwell, & Tangherlini, 2012).

Enthusiasts of home-made textiles use the Internet to find patterns or to learn how to make them. Many of these practitioners support blogs or web-sites to exchange information, to offer their production. Moreover some companies have developed software applications for Computer-aided design of home-made textiles. Such applications are named **knitting software** (Soft Byte LTD, 2012), (EnvisioKnit, 2017) (Stitchmastery, 2014) and **crochet software** (Send Castle Design, 2015), (Stitchworks Software, 2015). Crochet software as well as knitting software gives the possibilities to create a crochet and knitting diagrams and instructions. Crochet diagrams are graphic representations of project patterns, consisting of multiple and often repeated symbols. Each symbol corresponds to a crochet stitch. One of the main problems in crochet and

knitting software is how to represent symbols. . Existing applications are equipped with image editors containing a set of stitches, which only developers can modify. It is impossible to share stitches between programs because each application supports its own data format. Some applications allow exporting crochet diagrams to PDF files or to an image file such as JPEG or PNG (Stitchmastery, 2014). Using an internal graphics description leads to platform dependency, and so an inability to reuse the created projects and difficulties in modifying existing graphic primitives or creating new ones describing stitches.

Some developers suggest Knitting and Crochet Symbol Fonts, containing multiple (as soon as possible) knitting or crochet symbols (Adriprints Press), (FFonts, 2012), (Kauricat Knits), (Brown-Reinsel). This would overcome the shortcomings listed above. Moreover, each font can be used for editing knitting or crochet charts by using multifunctional software applications such as any word-processors, MS Excel, Adobe Illustrator, Adobe Photoshop, Adobe InDesing, and so on. The using of symbol fonts to present knit and crochet chart symbols, however, has some disadvantages. The main problem is that the users are restricted to use only the existing symbols, which they cannot modify or add to. This creates a serous disadvantage because a lot of stitch combinations cannot be created. This especially true for the crochet symbol fonts, where there are a great variety of stitches combinations (FFonts, 2012).

For the presentation of knitting symbols an XML-based language, or Portable Knitting Format (PKF), has been introduced (Zaharieva-Stoyanova & Bozov, 2015). PKF is applied to the description of existing knitting symbols, while giving a possibility to create new ones. This paper explores the extension of PKF to the description of crochet symbols. Compared with knitting symbols diagrams, crochet diagrams and symbols have their own features. The main aspects of crochet diagrams that make them distinct from knitting diagrams are: a) Generally, crochet symbols are not placed on the raster grid; b) Each crochet symbol can be rotated; c) Some basic crochet symbols are used and they can be combined many different ways. Due to these facts, it's necessary to make changes in PKF for the application of crochet symbols description. This paper describes a newly developed XML-based language which can be used to describe existing and creates new crochet symbols, but also to create different stitch combinations included in crochet.

2   Graphic Representation of Crochet Symbols and Diagram

In general, a crochet diagram follows the shape of a real crochet pattern. It is built of crochet symbol sequences. Each symbol corresponds to a crochet stitch. Crochet symbols as well as knitting symbols are a type of semi-graphical characters. The most frequently used crochet symbols were standardized by Craft Yarn Council (Yarn Standards, 2015). On the whole crochet symbols are stylistically similar to the corresponding stitch. Examples of crochet stitches are given in fig. 1 and fig. 2.

Due to their singular features, crochet diagrams are distinct from knitting charts. The main differences are the following:

- Generally, crochet symbols follow a sequence, which is not placed in rectangular area, so, they can't be put on a rectangular grid. While rectangular patterns exist, crochet patterns described on a rectangular grid are the exception.
- Each crochet symbol can be rotated. The crochet chart graphically represents a crochet pattern, with symbols corresponding to the placement of stitches. Crochet can run in circular as well as square patterns, following different shapes – circles, ovals, rectangles and so on. To build a shape, the symbols must be rotated. Regardless of the transformation, the symbol remains the same. Unlike in knitting charts, a knitting symbol will be transformed into another one after rotation.
- Through the use of the basic existing crochet symbols a great variety combinations can be made. Some crocheters call the combinations of stitches *clusters*. In this paper, the term "*cluster*" will be used for a certain combination of stitches. The developers of crochet symbols fonts treat a crochet cluster as a single stitch. This allows for the number of characters in the font to increase enormously. For example, *Stitchin Crochet font* has over than 90 symbols (Adriprints Press) without being guaranteed that all the symbols are included in the font).
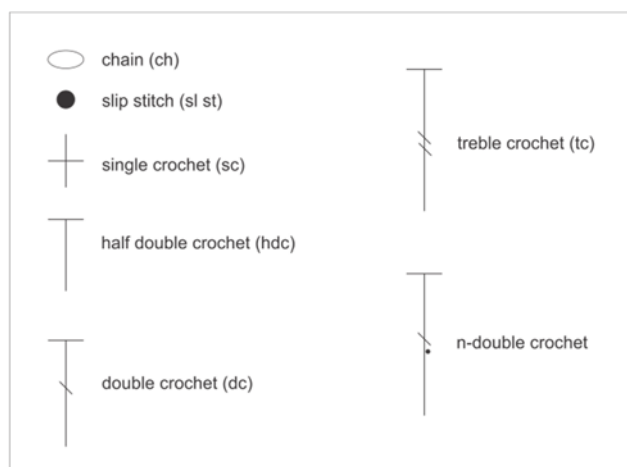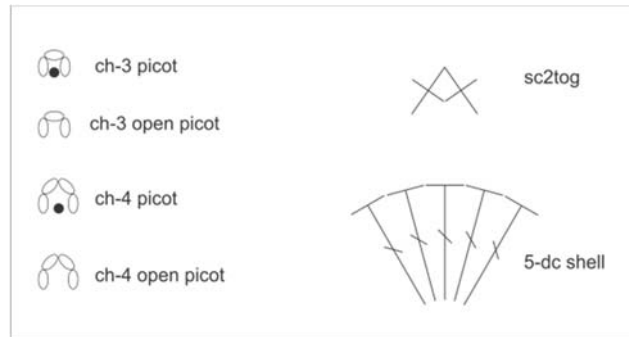

Fig. 1. The basic crochet symbols.

Fig. 2. Examples of clusters.

Notwithstanding the fact that crochet charts may include multiple different symbols, some basic symbols are commonly used. The basic most common used symbols are given in fig. 1. They are: chain, slip stitch, single crochet, half double crochet, double crochet. One more yarn over lengthens a double crochet and turns it into treble crochet. Thus a treble crochet can be stretched to a double treble crochet and so on. The differences between double and treble crochet symbols are: the height and one more back slash. We suggest the introducing of n-double crochet symbol as a universal symbol for double, treble, and double treble crocheting (see fig. 1). The value of n determines the height of the symbol and the numbers of backslashes. Using this symbol crochet software can generate a number of similar crochet symbols.

As mentioned above, the basic crochet symbols can be combined to form clusters. The most common clusters are: picot, open picot, shell, , some stitches together, and popcorn. Picots are formed by n-chains ending with a slip stitch where n is equal to or greater than 3. If there isn't a slip stitch the picot is open (see fig. 2). Shells are formed by n double or treble crochets as it shown in fig. 2. Some single, half double, double, treble and so on crochets can be ended together to form a new cluster. Combining the basic crochet stitches leads to a great variety of clusters. For example, it is possible to make different types of X or Y-shaped crochet clusters. The creation of different types of cluster stitches depends mainly on the practitioners experience and skills. It's not a good idea to create a different symbol for each crochet cluster for computer representation. On the one hand, this restricts users' ability to create new cluster, on the other hand, it would lead to an unreasonable increase in the number of characters required.

3 Application XML-base Language for Description of Crochet Symbols

The paper offers an extension of XML-based language for describing and serializing the bitmaps corresponding to different types of crochet stitches. XML allows unification and a platform-independent way for the description of the structure of stitches. The developed Portable Knitting Format contains the XML elements describing graphic primitives: line, polygon, polyline, arc, ellipse, rectangle, and Bezier curve (Zaharieva-

Stoyanova & Bozov, 2015). Using all these primitives the editor can describe all possible knitting or crochet symbols. XML elements describing graphic primitives are given in Table 1.

Table 1. XML elements describing graphic primitives.

XML element	Prototype
Line	\<Line StartPoint="" EndPoint="" Stroke="" StrokeThickness="" />
Rectangle	\<Rectangle StartPoint="" Width="" Height="" Stroke="" StrokeThickness="" Fill="" />
Ellipse	\<Ellipse StartPoint="" Width="" Height="" Stroke="" StrokeThickness="" Fill="" RenderTransformOrigin="" Angle="" />
Polygon	\<Polygon Points="" Stroke="" StrokeThickness="" Fill="" />
Polyline	\<Polygon Points="" Stroke="" StrokeThickness="" Fill="" />
Arc	\<Arc EndPoint="" Size="" RotationAngle="" IsLargeArc="" SweepDirection="" Stroke="" StrokeThickness="" Fill="" />
Bezier	\<Bezier Point1="" Point2="" Point3="" Stroke="" StrokeThickness="" />

A polygon description requires Points – a Collection that contains the vertex points of the polygon. The accepted value is Points (e.g. Points ="1,50 10,80 50,50"). EndPoint – Sets x and x coordinate where the Arc ends (e.g. EndPoint=(100,100)).

Arc description requires:

- Size – Set the x- and y- radius of the arc as a Size structure (width and height). The accepted value is size (e.g. Size ="50,25").
- RotationAngle – The x-axis rotation of the ellipse. The accepted value is double (e.g. RotationAngle ="90").
- IsLargeArc – Whether the arc should be greater than 180 degrees. The accepted value is Boolean (e.g. IsLargeArc ="True").
- SweepDirection – Defines the direction that an elliptical arc is drawn. The accepted values are Clockwise and Counterclockwise (e.g. SweepDirection="Clockwise")

Bezier description requires:

- Point1 – First control point of the curve (e.g. Point1="100,0").
- *Point2* – Second control point of the curve (e.g. Point2="200,200").
- *Point3* – End control point of the curve (e.g. Point3="300,100").

The XML element KEelement corresponds to a stitch. The KEelement contains Description (optional) and one or more graphic primitives (Line, Rectangle, Ellipse, Polygon, Polyline, Arc and Bezier). Every KElement can override Width, Height, Stroke, StrokeThickness and Fill. The representation of three of the most commonly used crochet symbols *single crochet*, *double crochet* and *chain* by XML-based language is:

```
<KElement Id="5e059e98-e957-4c5a-ac63-c7fd53bbaf6e"
```

```
Fill="255,255,255" Stroke="Black" StrokeThickness='1'>
    <Line StartPoint="15,2.5" EndPoint="15,17.5" />
  <Line StartPoint="10,10" EndPoint="20,10" />
</KElement>
<KElement Id="c1e5e18f-df33-4d2b-8a81-1792a1ec7386"
Fill="255,255,255" Stroke="Black" StrokeThickness='1'>
  <Line StartPoint="45,2.5" EndPoint="45,32.5" />
    <Line StartPoint="40,2.5" EndPoint="50,2.5" />
  <Line StartPoint="42.5,15" EndPoint="47.5,20" />
</KElement>
<KElement Id="242d5ca8-1a65-474e-b6c5-1ece75b29d97">
  <Ellipse StartPoint="85,2.5" Width="10" Height="5"
Stroke="Black" Stretch="Fill" /> </KElement>
```

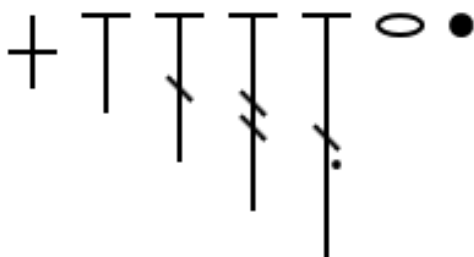Figure 3 represents the results of the XML representation of crochet symbols.

Fig. 3. The result of XML description of the basic stitches

The root element describing crochet or knitting pattern is **KScheme. KScheme** describing a knitting diagram can contain the following XML elements: **Description** (optional), **KTemplate** (optional) and **KGrid** (required). **Description** is an XML element, which allows incorporation of Meta information. It can contain only text. **KTemplate** describes different stitches and knitting formed as blocks. Practically, they realize the knitting structure and correspond to the pattern drafts. KTemplate can contain Description (optional), KElementTemplate(optional) and KBlockTemplate(optional). **KScheme** describing a knitting diagram can contain the following XML elements: **Description** (optional), **KTemplate** (optional) and **KRowTemplate** (required).

Another XML element – **KRowTemplate** describes a set of crochet rows. An XML element **KRow** can contain as many as needed KElementTemplate and KClusterTemplate XML elements. An XML element **KClusterTemplate** describes a set of KClusters. An XML element KCluster corresponds to a crochet cluster. A **KCluster** contains **Description** (optional) and a set of KElements (required). The programming

code representing the first cluster in figure 4 is as follows:

```
<KCluster Id="a42d5c68-16d5-a744-b6c3-1e1e75b26797"
Stroke="Black" StrokeThickness='0.3'>
<KElement Id="242d5ca8-1a65-474e-b6c5-1ece75b29d97">
  <Ellipse StartPoint="100,2.5" Width="10" Height="5" />
</KElement>
<KElement Id="242d5ca8-1a65-474e-b6c5-1ece75b29d97">
  <Ellipse StartPoint="97,5" Width="5" Height="10" />
</KElement>
<KElement Id="242d5ca8-1a65-474e-b6c5-1ece75b29d97">
  <Ellipse StartPoint="108,5" Width="5" Height="10" />
</KElement> </KCluster>
```


Fig. 4. The result of XML description of clusters: 3 ch-open picot, 4-ch picot, 5-dc shell.

XML elements describing crochet diagram are represented in Table2. The examples of clusters created by using of XML-based language are given in fig. 4.

Table 2. XML elements describing crochet diagram.

XML element	Prototype
KScheme	<KScheme> </KScheme>
KTemplate	<KTemplate></KTemplate>
KEelementTemplate	<KEelementTemplate Name="" Id="" Width="" Height="" Stroke="" StrokeThickness="" Fill=""> </KEelementTemplate>
KEelement	<KEelement Name="" Id="" StartPoint="" Width="" Height="" Stroke="" StrokeThickness="" Fill=""> </KEelement>
KClusterTemplate	<KClusterTemplate Name="" Id="" Width="" Height="" Stroke="" StrokeThickness="" Fill=""> </KClusterTemplate>
KCluster	<KCluster Name="" Id="" StartPoint="" Width="" Height="" Stroke="" StrokeThickness="" Fill=""></KCluster>
KRowTemplate	<KRowTemplate Name="" Id="" Width="" Height="" Stroke="" StrokeThickness="" Fill=""> </KRowTemplate>
KRow	<KRow Name="" Id="" StartPoint="" Width="" Height="" Stroke="" StrokeThickness="" Fill=""></KRow>

XML-based language describes not only the graphic primitives but also their method of visualization. They do not depend on particular application programming interface. This leads to the platform-independent way for description and visualization. The suggested format is particularly suitable for describing crochet symbols. Graphic primitives are described in vector format, in which there are possibilities for creating combinations of symbols, and graphic character transformations are allowed. Combining some crochet symbols as a cluster is a key element in the description of crochet diagrams. Clusters of crochet stitches are parts of crochet patterns, sometimes crochet patterns can consist of just one or a few clusters.

4   Conclusion

Traditional home crafts and occupations are part of the cultural heritage of many countries. Knitting and crochet are one of the most famous and widespread home crafts. Nowadays people who practice such traditional home crafts often use computer programs to view or to create patterns of their works. There are applications of knitting and crochet software designed for Computer-aided design of knitting and crochet patterns. One of the problems related to the development of this kind of software program is the digital representation of the patterns and particularly, the representation of different types of stitches. For the representation of knitting patterns the XML-based language named PKF was developed. This paper suggests an extension of the XML-based language for the description of crochet symbols. Due to the crochet symbols' features the suggested format is particularly suitable for their description. This is a better solution than the use of crochet symbols fonts, where each combination of stitches forms a single character. XML-based description uses several basic symbols and offers the possibility of creating different types of crochet stitches combinations. The XML-based language can be developed to be embedded into crochet software.

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