A document format for sewing patterns

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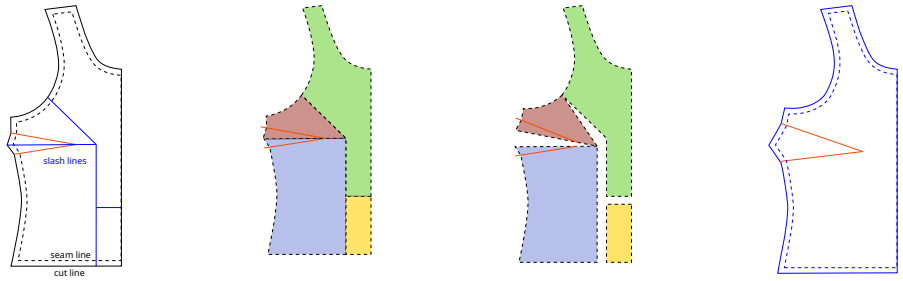

(a) Seam and slash lines added **(b) Seam allowance removed, piece slashed** **(c) Segments spread to add room at bust** **(d) Final piece with seam allowance added**

Figure 1: Typical process for performing a full bust adjustment on a bodice block [1]. Armscye and side seam lengths are maintained while adding more ease in the bust region.

ABSTRACT

Sewing patterns are a form of technical document, requiring expertise to author and understand. Digital patterns are typically produced and sold as PDFs with human-interpretable vector graphics, but there is little consistency or machine-readable metadata in these documents. A custom file format would enable digital pattern manipulation tools to enhance or replace a paper based workflow.

In this vision paper, basic sewing pattern components and modification processes are introduced, and the limitations of current PDF patterns are highlighted. Next, an XML-based sewing pattern document format is proposed to take advantage of the inherent relationships between different pattern components. Finally, document security and authenticity considerations are discussed.

CCS CONCEPTS

• **Applied computing** → **Extensible Markup Language (XML)**;
• **Information systems** → **Document structure**.

KEYWORDS

PDF, XML, document structure, vector graphics, sewing patterns

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1 INTRODUCTION

Sewing as a hobby has grown in popularity from the late 1990s onwards [2], with an increased surge of interest occurring during the COVID-19 pandemic [3]. In the same time frame, several technological innovations have occurred, including social media, parametric pattern generators, projector sewing, and the topic of this paper: digital sewing patterns.

Traditional sewing patterns were printed on large-format tissue paper and sold in stores, an expensive process available to only a few large companies [4]. As more sewists joined various online communities, independent or "indy" designers began selling their patterns as portable document format (PDF) pages that can be printed at home and taped together. This has become the preferred format for many sewists [2].

Projector sewing, in which the pattern is projected from the ceiling to the fabric directly, began as an experiment by a single sewist, Missy Pore, in late 2019. Her Facebook group "Projectors for Sewing" has over 65k members as of July 2023, and many indy designers offer PDFs specifically formatted for use with a projector. Recently, a commercial sewing-specific projector was developed by Singer and JoAnn stores [5]. Their Ditto system includes the hardware and a subscription service to their patterns.

The most common[1] question asked by projector-curious sewists is "how do you do alterations?". Sewing patterns are sometimes cut and sewn as-is, but more commonly the patterns are adjusted to fine-tune the fit or modify the style. With paper patterns, modifications are done by "slashing and spreading" the paper pieces as illustrated in Figure 1 [1]. While this is possible to replicate digitally using

[1]As observed from my interactions with the sewing community.

vector graphics software such as Inkscape [6], it relies on the pattern pieces having well-formed closed curves as well as vector graphic experience on the part of the sewist, neither of which is typical.

While user-friendly software will be an important part of enabling digital sewing pattern manipulations, PDF patterns need further parsing to introduce the semantic information required to replicate the paper-based workflow. Additionally, abandoning the model of a static pattern opens the doors for enhancements such as language translations, preferred symbol depiction, adaptable seam allowances, fabric- or paper-efficient layouts, and more.

This vision paper proposes an extensible markup language (XML) based sewing pattern file format to be developed as an open standard for sewing pattern information exchange. This format will also serve as the target for upcoming PDF pattern parsing tools.

2 BACKGROUND

2.1 Previous work

There are several examples of parsing sewing patterns in the literature, most with the objective of creating 3D renderings from 2D pattern pieces [7, 8, 9]. While producing impressive results, these processes are not intended to be used by home sewists, and are also limited in the input format of the patterns.

A recent paper by Leake et al. does address user-friendliness and pattern piece extraction from PDF or scalable vector graphic (SVG) files with "InStitches" [10]. In this work, the pattern pieces are separated from information markings by finding the outermost closed curve of each piece. InStitches also employs a heuristic to identify fold lines and pattern labels, while corresponding seam lines rely on manual labelling. This forms an impressive basis for PDF pattern parsing, but the primary objective of guiding sewing practice would be facilitated by a sewing-specific document format.

2.2 Current file formats

There are two primary types of digital sewing patterns: Traditionally drafted (TD) or parametrically generated. Parametric pattern generators (PPGs) allow the user to enter measurements and select options to generate a custom-fit pattern. TD patterns are created by a trained expert either on paper, in a general-purpose graphics program, or using a sewing-specific computer aided drafting (CAD) program. TD patterns are more common, with only a few PPGs on the market [11, 12, 5, 13].

To understand and ultimately be able to interpret a range of TD patterns, we are labelling a database of patterns acquired by permission from designers. At the time of writing, we have collected approximately 80 samples from 30 designers, representing a response rate of 30%. These files are primarily "American style" patterns from the Anglosphere.

For TD patterns, PDF is the *de facto* standard, but there is little consistency between designers. In our dataset, 80% were produced by various flavours of Adobe Illustrator and 76% use optional content groups (OCGs) to distinguish between different sizes. However, only 5 designers included metadata such as Author in their files, suggesting that rendered appearance and not PDF structure is a priority for most designers. While PDF could be enhanced to add sewing-specific metadata, the highly variable structure makes modifications challenging, and it is better suited as a final output format [14].

PPGs also typically produce PDFs, with some offering the option to download an SVG [11, 13]. As patterns can be well-represented with SVG, itself a variant of XML, SVG is a strong candidate as a file format. However, maintaining compliance with the SVG standard restricts the file structure and pattern-specific information that can be included, and a custom format incorporating SVG elements is proposed as a compromise.

Commercially, many sewing-specific CAD programs export and import drawing exchange format (DXF) files in addition to having their own custom files [15]. One such CAD program is the open source Seamly2D, which uses an XML-based file format [16]. Custom JavaScript Object Notation (JSON) files have also been used to describe patterns for research purposes [9]. While each of these file formats is text based with open documentation, they are intended as an intermediate interchange format between industry professionals or hobbyist pattern drafters; they are not intended as an end product for use by home sewists. Similarly, file formats for other sewing tasks such as embroidery could be considered candidates, but these are intended for machine processing and do not include instructions for rendering for viewing [17].

2.3 Anatomy of a Sewing Pattern

Sewing patterns provide a wealth of information to the experienced sewist. In broad terms, there are three categories of information on a pattern piece, depicted as different colours in Figure 2: piece contour (black), markings (orange), and annotations (blue).

This example of a TD pattern piece shows three sizes of a simple bodice. Two different "views" are illustrated: scoop neck or v-neck. Multiple views are common in TD patterns, allowing the sewist to purchase a single pattern with different style options. However, alternative views pose a technical challenge, as the pattern piece is no longer a closed curve but a combination of a closed curve with a disjoint line. To add to the confusion, American-style patterns depict pattern pieces as a *cut line* with the seam allowance (SA) included, while European-style patterns use the *seam line* as the reference, relying on the sewist to add SA as desired.

Markings such as the small triangles of Figure 2, called "notches", or the larger triangular *darts*, are size-specific information that needs to be transferred to the fabric during the cutting process. However, annotations for information (shown in blue) are not marked on the fabric. For example, the line marked "grainline" is instructing the sewist how to align the piece with the warp threads of the fabric.

In a typical PDF pattern, each size is distinguished by a difference in line style, colour, defined within OCGs, or a combination of all three. However, this simple grouping does not allow for separation of cut lines from markings, and elements common to all sizes are typically grouped with the annotations layer. Furthermore, the information on different views is often scattered between pattern annotations, piece labels, or within accompanying instructions. Finally, stylistic choices used to represent common elements vary significantly; for example, Figure 3 shows six different notch depictions from our collected dataset.

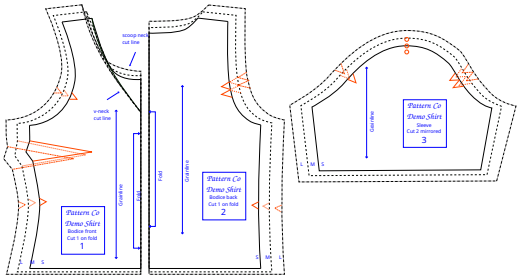

Figure 2: A sample bodice pattern piece in 3 sizes. Colours are used here differentiate different types of information.

Figure 3: A sampling of notch depictions.

2.4 Basic pattern manipulation

There are several approaches to adjusting patterns to custom fit an individual. One common approach is the "slash and spread" technique, illustrated in Figure 1. Slashing and spreading involves the following steps [1]:

(1) Draw the seam line inside the cut line by offsetting each raw edge by the given SA[2] (Figure 1a).
(2) Draw slash lines on the pattern piece according to the desired modification (Figure 1a).
(3) Cut the pattern apart along slash lines and either cut away or ignore original cut lines (Figure 1b).
(4) Spread or overlap segments, maintaining pivot points along key seam lines such as the armscye (Figure 1c).
(5) Trace the outline of the new pattern piece to create a new closed contour (Figure 1d).
(6) True the seam lines and add SAs (Figure 1d).

"Truing" ensures that the modifications still allow for accurate garment construction. In short, truing is the process of smoothing out any abrupt transitions introduced by modifications, then comparing adjoining seams to make sure they still line up and are the same length (or have the same amount of ease) [1].

Other forms of pattern manipulation include lengthening or shortening, grading between sizes, colour blocking, pattern "mash-ups" (i.e. combining pieces from different patterns), and pattern "hacking", or making significant style alterations to a base pattern.

Technical sewing training is required for much of the above, such as knowing where to place slash lines and pivot points. However, performing these steps in vector graphics software adds on a new set of required computer skills, made particularly challenging by the current pitfalls of PDF patterns.Importing a PDF pattern into vector graphics software often results in a set of disjoint lines nested into many groups, or in particularly egregious cases, "lines" are not actually lines at all but a series of skinny rectangles.

[2]Removing SAs is not required for European-style patterns.

3 DESIGN OF A NEW DOCUMENT FORMAT

This section describes some of the high level components of an XML-based sewing pattern file format. This is by no means a complete specification, and the ultimate form will surely change after feedback and testing from developers, pattern designers, and end users.

3.1 Pattern element hierarchy

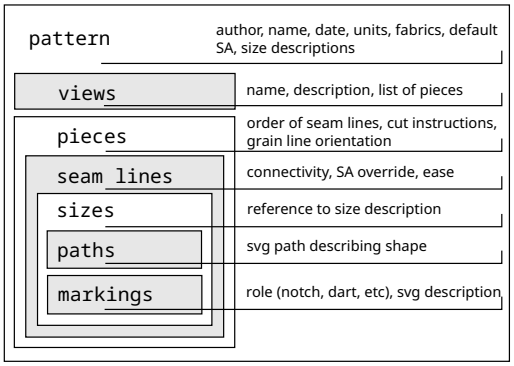

Figure 4: Overview of the hierarchy of pattern elements in the proposed XML format.

Based on the entities present in our pattern database and borrowing concepts from FreeSewing [11] and Seamly2D [16], the hierarchy shown in Figure 4 is proposed. In this model, the root `pattern` element contains a number of global pieces of information, such as measurement units, default SAs, description of sizes and fabrics, etc. The `view` elements list the pattern pieces included in each style offering, while the bulk of the pattern is then composed of the pattern pieces themselves, which in turn are made up of `seam lines`. SVG path syntax is used to define the seam lines and markings at each `size`.

In a typical PDF pattern with OCGs, each pattern piece is drawn within a *size* OCG. In the proposed format this structure is inverted, with `size` appearing as the second-last level before the terminal `path` element. This is because pattern pieces and seam lines share various properties at different sizes, such as connections to other seam lines, amount of ease, number of pieces to cut, whether to place on the fold, and more. It is only when it comes time to draw the actual outlines and associated markings that size plays a role.

In contrast to open source drafting tools Seamly2D [16] and FreeSewing.org [11], `seam lines` are chosen as the fundamental graphic object rather than `points`. In these formats, the shape of the pattern is defined as a series of points and associated connectivity, with each size varying only the coordinates of the points. This is a good choice for pattern drafting software with complete control over the end product, but when parsing TD patterns there is no guarantee that the original design was created in this manner. Furthermore, allowing for arbitrary path definitions at each size also provides flexibility such as adding darts in sizes with more curvature.

To represent a pattern piece, a closed path is essential. To ensure this, each seam line must begin and end with the same point as the

previous. An obvious solution would be to forego the seam lines and construct each piece as a single closed path, but this would make seam information more challenging to define. As a compromise, each pattern piece element in the proposed format would contain a list referencing the order of seam lines; these can be parsed to create a closed curve.

Notably, the proposed format does not include vector graphics to describe annotations such as grain lines. Instead, this information is treated as metadata to be drawn at render time. This allows for language translations and preferred rendering styles as well as more advanced processing, such as automatic fabric-efficient layouts with fold and grain line awareness.

The XML hierarchy proposed here has the flexibility to include custom sizes, allowing for the sewist to define new seam lines where needed to optimize fit or style. Custom views could also be defined to mix and match different pattern components, possibly even combining different patterns. Such modifications would perhaps be best implemented in a sidecar file that references the original pattern, allowing for sewists to share modifications and mash-ups without violating usage agreements by sharing the original pattern.

3.2 Security and authenticity

In my correspondence with pattern designers, several brought up concerns of malicious use such as rebranding or slightly modifying patterns and reselling. A service such as Ditto [5] addresses this issue by offering patterns as a subscription service, but this runs counter to the goal of an open standard and accessible file format.

25% of the patterns in our database use some form of PDF encryption, requiring a user password and/or restricting actions such as copying. However, PDF security relies on the software to enforce [14], and poses more of a roadblock to honest users than a true impediment to malicious use. While there is always a way around any form of security, designing a sewing document format without considering security would be ignoring the valid concerns of the intended format's authors.

The core of a pattern is primarily in the paths defining the pattern pieces themselves. With careful selection of SVG user unit scale (e.g. 1 unit = 1 mm), it is likely that only 0-1 decimal place of precision is required, as fabric cutting cannot be done with sub-millimetre accuracy. This opens up the possibility for a steganographic signature in the extraneous decimal places, for example using the algorithm described in [18]. While this would not actually prevent copying, it could serve as a source of authentication, e.g. by encrypting the author's signature and comparing to the plaintext authorship information.

4 FUTURE WORK

As this project is currently in the ideation phase, significant future work remains for the proposed format to become a viable solution. While authoring tools will eventually be required, the next step will focus on a conversion tool from current PDF patterns. Many designers are solo operations with large catalogues, and expecting them to re-publish old patterns with considerable added metadata is not practical. However, a mostly automated conversion process with some manual cleanup may be more palatable, particularly if end users wishing to work with a specific pattern are performing the conversion.

The other obvious future work is the development of tools that read and write the proposed format. Once tools are implemented e.g. through an Inkscape [6] plugin or purpose-designed software like InStitches [10], limitations of the document format will surely be revealed and significant modifications may be made.

Finally, a standard is only useful if it is adopted. To that end, a version of this paper and associated sample files, schemas, and tools will be made openly available in order to solicit feedback and attract suggestions from pattern designers, sewists, and sewing software developers.

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