

MOBILE DISPLAY OF KNITTING PATTERNS

BACHELOR'S THESIS

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540609

16 AUGUST 2016

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INTERNATIONAL MEDIA AND COMPUTING (BACHELOR)

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Chapter 1

Introduction

Since the beginnings of the 2000s knitting has encountered a steady rise in popularity. This might be due to the rise of the internet and social media, and the increasingly important role they play in the daily life. The older knitting generation is adapting the technology and switching over, and bringing knitting as a craft and hobby closer to the younger generations (Lewis 2011). Online communities like Ravelry¹ and YouTube² teach the knitting enthusiasts knitting techniques and patterns of all kinds — never has knitting knowledge been more accessible.

Considering this it is all the more surprising that there are only few apps related to knitting to be found on the Play Store, Google's digital distribution service for Android apps. Mobile devices have the potential to be a great help to knitters: in an app they could keep track of the projects they are currently knitting, look up instructions, and store knitting patterns. The latter especially aids the mobile knitter — no longer is it necessary to carry sheets of paper with pattern charts or even books around.

The difficulty with displaying such a chart on a mobile device derives from the size of the device and its screen, which is a far smaller medium than a sheet of paper, on which pattern charts are normally printed. The charts are therefore too big to be viewed easily inside an app. The goal for this thesis is to research how a knitting pattern chart can be input and displayed on mobile devices running the Android operating system.

¹<http://www.ravelry.com/>

²<https://www.youtube.com/>

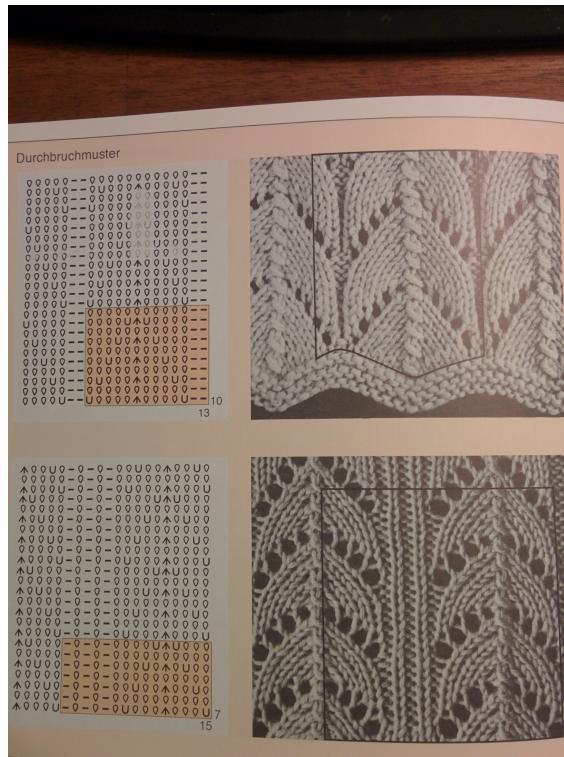


Figure 1.1: Knitting patterns and their corresponding pattern charts from Natter 1983, p142

Chapter 2

Background

2.1 Definition of Knitting Pattern and Knitting Pattern Chart

A knitting pattern specifies a set of instructions outlining the steps necessary to create a knitted textile or fabric. For knitting a fabric the knitter uses two or more knitting needles and a long, continuous strand of yarn which he uses to form intersecting loops with, which in turn creates a textile or fabric. “Knitting is a conversion system in which yarn loops are interwoven to form a fabric” Raz 1993, p17. The type of loops the knitter uses as well as the kind of yarn determine the attributes of the knitted piece: elasticity, form and texture. A knitted fabric can be stretched in both horizontal and vertical directions, as well as the directions in-between. This makes it stand apart from woven fabric, which is created by layering two threads in an interlaced manner; the resulting cloth is very limited in its ability to stretch and be formed, excluding, of course, the usage of stretching threads. Knitting patterns can come in form of written instructions, usually with abbreviations used for the stitch terms, e.g. k2tog for the “knit two together” stitch, or in form of a pattern chart which consists of a grid filled with symbols. Both, written patterns and pattern charts, are generally split into rows, where each row has a definite number of stitches. Each cell in such a grid signifies a stitch in the pattern and the symbol displayed in a cell corresponds with the stitch that needs to be made in that place in the pattern. In what order the rows have to be knitted depends on the chart type; some charts display only the uneven numbered rows, which belong to the right side (RS) of the knitted fabric, and expect the knitter to knit the

return row on the wrong side (WS) inverse to the RS, i.e. knits would be knitted as purls and purls as knits. Other charts show all rows, the uneven numbered for the RS and the even numbered ones for the WS.

So far there doesn't exist an international standard for the symbols used in knitting charts or the abbreviations in written instructions. Symbols used by the industry usually vary depending on the region Raz 1993, p57. and it is the norm that a knitting pattern includes a glossary for the symbols and abbreviations used in the pattern. Singular exception to this is Japan, where there exists a Japanese Industrial Standard on knitting symbols used in the industry and for the hobby hand knitters: JIS L 0201-1995 Association 1995. This leads to the fact that Japanese knitting pattern charts are published without an index of the symbols used.

Other regional industry standards that Raz mentions in his book are the German Standard and the needle notation system, "the most explicit and accurate of all notation systems" Raz 1993, p58., which is solely used for industrial knitting and shows the positions of the needles of the knitting machine for each stitch.

2.2 Comparison of existing Android solutions

2.2.1 Android apps

When searching for the term "knitting" in the Google Play Store, Android's official source for Google-approved applications, few results will pop up. Next to a surprising amount of games about knitting, there are apps for knitting counters, knitting patterns and knitting instructions for those who wish to begin knitting. The following sections will look at the top five apps for creating and managing knitting projects with row counters and pattern display, as well as knitting chart creation.

knit tink — Row Counter by Jennifer K. Warren

Out of all most popular knitting apps, knit tink features the most modern and clean design. The app can be used for free or bought as an ad-free pro version. Features include the creation, editing, viewing, and deletion of projects, the setup of one row, and one repeat counter per project, as well as the unlinking of the row counter from the repeat counter. The free version of the app restricts the number of projects to three.

The developer announced an on-screen display of a knitting chart in PDF format as an upcoming feature.

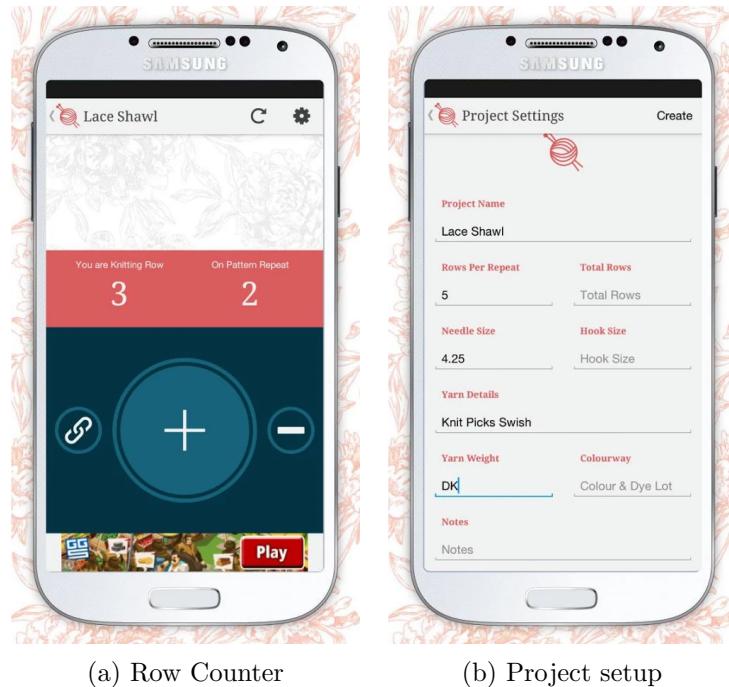


Figure 2.1: Screenshots of the app knit tink

Knitting Counter by mkacki

Knitting Counter offers the same features as the knit tink app, the only differences being the layout of the user interface and the option to keep the phone from going into sleep mode, i.e., turning the phone screen off.

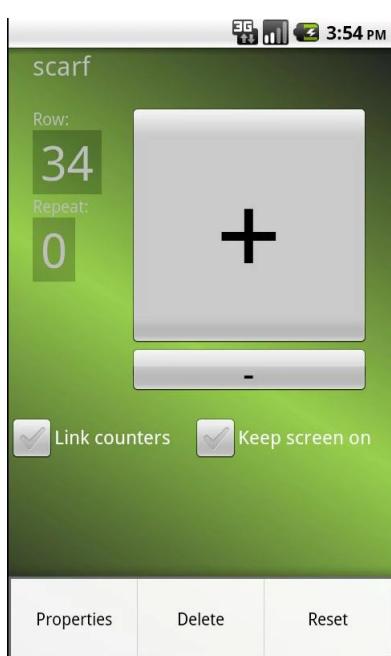


Figure 2.2: Counter of Knitting Counter

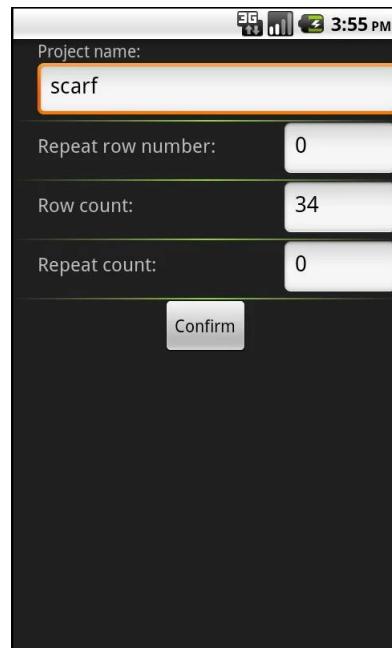


Figure 2.3: Counter set up screen of Knitting Counter

2.2.1.1 Knitting and Crochet Buddy by Colorwork Apps

The Knitting and Crochet Buddy contains a plethora of features related to knitting and crocheting. As is the standard with the previous apps, it offers the possibility to manage different knitting and crocheting projects, with each a row and a repeat counter per project. Users can also enter written instructions or add a picture of the pattern chart to be displayed on the counter screen.

Additional features include, but are not limited to: yarn and crochet charts, an abbreviation chart, size charts for knitting needles and crocheting hooks, a project timer, a ruler function, and a flashlight.

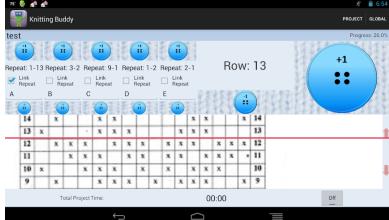


Figure 2.4: Counter of Knitting Buddy with written instructions

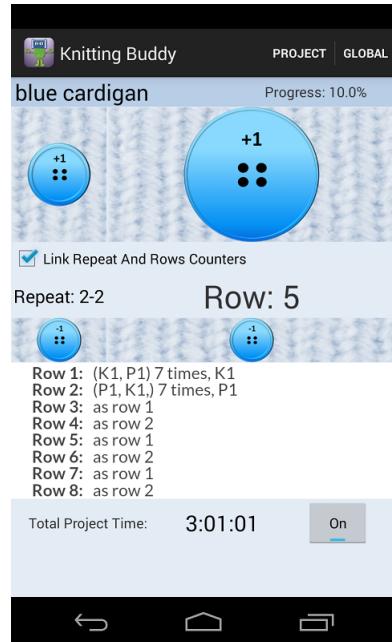


Figure 2.5: Counter of Knitting Buddy with chart picture

2.2.1.2 BeeCount knitting Counter by knirirr

BeeCount differs from the standard of one row counter per project in that it allows multiple counters. Those counters can be for parts of the knit piece that belong to the same project, as is the case for a knitted sweater, for example. These counters within a project can be linked together, so that increases or decreases in one counter affect the row number of another counter (figure 8). Furthermore, alerts can be set on counters to be triggered once the counter reaches a set number.

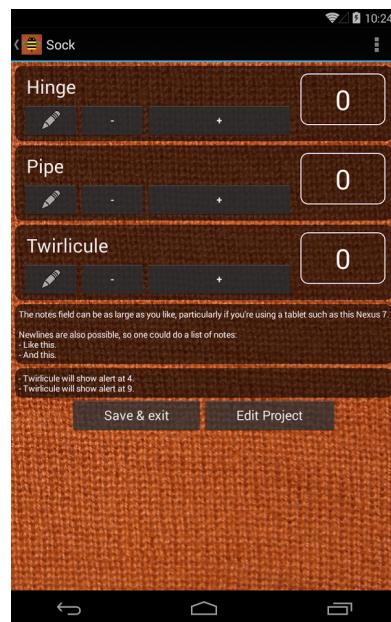


Figure 2.6: Counters of BeeCount



Figure 2.7: Counters set up of BeeCount

2.2.1.3 Knitting Chart Maker by Awesome Applications

When it comes to pattern charts, none of the aforementioned apps offers a solution besides the possibility to include a picture of a pattern. Therefore, I looked at Knitting Chart Maker, an app that focuses solely on the creation and editing of charts.

The app has over 30 stitch symbols that the user can use to create a pattern chart. The symbols are defined by the app and are not taken from a standard. The user can't devise their own stitch symbols. Symbols can be used by selecting the symbol in the left-hand menu and then transferred onto the grid by tapping on a cell. Alternatively, the user can select the paintbrush button on the top-left menu and use their finger to paint the symbols onto every cell touched in a swiping motion, not unlike drawing with a pencil. The whole grid is zoomable up to a certain zoom level.

While in-app, the user can purchase the pro version which allows them to save and export patterns. Charts can be exported in the form of written instructions or a picture. Included are also various sharing features, such as uploading the saved chart to Dropbox, or sharing a chart with a friend, who can then open that chart in their paid copy of the app.

The app is locked in landscape mode and the chart dimensions are limited to 50 x 50. The pattern chart grid is implemented using OpenGL's canvas and drawing images at the cell positions.

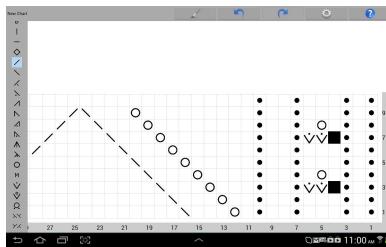


Figure 2.8: Chart editor of Knitting Chart Maker

2.2.2 Other

2.2.2.1 KnitML by Jonathan Whitall

KnitML is an XML based format for describing the knitting process from beginning to the finished product. With KnitML The project aims to establish an international

standard for knitting pattern expression¹. He aims to do so by using the Knitting Expression Langauge, KEL, that he defined (Whitall 2009). KEL is based on the Groovy programming language² for the Java platform and the GroovyMarkup architecture.

The following KEL expression

```
1 Pattern {
2     generalInformation
3 }
```

Listing 2.1: Example expression in KnitML

would result in

```
1 <pattern>
2     <general-information/>
3 </pattern>
```

Listing 2.2: Example expression in KnitM: XML result

The project has not seen updates in any form since 2013 and I presume it discontinued. A beta of an editor program for KEL and its resulting XML can be found on the homepage of the project, knitml.com.

¹<http://www.knitml.com/blog/static.php?page=about-knitml>

²<http://groovy-lang.org/templating.html>

Chapter 3

Requirements

3.1 Functional Requirements

The requirements for this thesis are formed from interviews conducted with volunteers at the beginning of this thesis. Three participants, stemming from both the author's acquaintances as well as from a poster posted publicly nearby the HTW's campuses, have been interviewed. Prerequisite for a participant in such an interview was a proficiency and an interest in knitting. During a time frame of 45 to 60 minutes the participants were asked to answer a set of questions concerning their knitting experience as well as what features they would like to see in an app aimed to aid them during the creation and viewing of a knitting pattern chart. For a transcript of these interviews consult the appendix A. From these interviews a set of functional requirements was extracted and listed below Chapter 3.1.

#	User Story	Functional Requirement
1	As a knitter I want to be able to see the knitting pattern chart on my phone while knitting	Display of knitting pattern chart that is easily usable while knitting
2	As a knitter I want to create my own charts in the app both in a grid format and a row format	Pattern editor for creating and editing patterns

#	User Story	Functional Requirement
3	As a knitter I want to transcribe charts from paper into the app with both grid and row formats	Pattern editor
4	As a knitter I want to have a list of all the patterns in the app and add and remove patterns from that list	CRUD for patterns and showing list of patterns
5	As a knitter I want to convert metric units for needle sizes, yarn weight and length to imperial and vice versa Unit converter in app	Unit converter in app
6	As a knitter I would like to enter a set of written knitting instructions and be able to see each individual instruction while knitting and jump to the next instruction with a button press	Editor for written instructions and view of them to be used while knitting with button or voice command
7	As a knitter I want to use my phone to count the rows I knit	Row counter
8	As a knitter I would like to be able to look up the explanations and visual instructions for different kinds of stitches while inside the app	Glossary of stitches with explanations and instructions
9	As a knitter I want to have a way to jump to the row I'm currently on in my knitting pattern and to get back to the default zoom level	Button for resetting the zoom level and to jump to current row when viewing a pattern
10	As a knitter I want to be able to take pictures of the finished, knitted products of a pattern	In-app camera and function for adding images from disk
11	As a knitter I want to be able to see pictures of the knitted products of a pattern	Gallery for knitted products from a pattern

#	User Story	Functional Requirement
12	As a knitter I want to have all my knitting projects with their details (pattern, required needle size and yarn, etc.) easily accessible in one app	Knitting project management functions
13	As a knitter I want to be able to use the row counter with another app in the foreground	Have row counter increase and decrease button in notification bar when knitting app is not the active app
14	As a knitter I want my screen to stay on until I exit the app	Force screen to stay on while in-app

Within the context of this thesis the focus lies on the functional requirements #1, 2, 3, 4, 8, and 7. The prototype of the app will present a functioning editor as well as a viewer for knitting pattern charts. Two input styles will be available for both viewer and editor: a grid style and a row style. The in the app generated pattern will be stored on disk and will be accessible with CRUD operations within the app. The viewer will have a row counter next to the displayed pattern chart. Buttons for switching between the view styles will be present in the editor as well as the viewer. The option to import and export pattern files will be available as well in case the user wants to move their patterns to or from a different Android device.

After these requirements will have been fulfilled and time allows, further features for the app will be: a button for resetting the zoom level and jumping back to current line in the pattern, a row counter increase and decrease button outside of the app and the option to force the screen to stay awake while within the app.

3.2 Non-functional Requirements

The prototype will store the pattern files locally on the device the app runs on. All prototype operation will run locally, connectivity to the internet is not needed. Internet connectivity is an option for a later version of the prototype, e.g. for backing the pattern files up to cloud storage and sharing patterns. Since this thesis focuses on the User Interface (UI) part of an app, storage will be restricted to simple, local solutions. This is also done to better fit the time restraints placed in this thesis.

Chapter 4

Design

The desired outcome of this thesis will be a working Android app prototype with working CRUD functions for knitting chart patterns and a row counter functionality while viewing a pattern. This prototype is intended as an aid for knitters of all backgrounds during their respective knitting projects. Patterns will be saved locally as a JavaScript Object Notation (JSON) file on the device's internal storage. It would also be an option to store patterns on a server and let the app play the role of client, but that would not fit within the time constraints of this thesis. To give the user the ability to backup their patterns the app will support the import and export of pattern from external storage. For a detailed explanation of Android's concepts of internal and external storage see section ???. Patterns exported will be accessible by the user and can be handled in whatever way the user sees fit to, for example, share or upload a pattern.

A chart pattern will consist of a set number of rows and columns. Each cell of the grid contains a symbol representing a knitting stitch. Created pattern are stored locally on the device and can be manipulated by the user in-app, as CRUD operations apply. Creating, editing and viewing patterns will be based on two shared visual formats for the pattern: a grid format and a row format.

The grid format will display the pattern in a grid, simulating the most common form of commercial distribution for knitting chart patterns on both analogue and digital media. Manipulation of the pattern content will be possible through a software keyboard containing the stitch symbols. A symbol can be selected and then applied to cells in the grid via touch. The symbol will stay active until the user selects a different symbol. The grid size can be changed with a button which opens a dialog where the desired amount

of rows and columns can be entered. On confirmation the grid will shrink or expand to the set dimensions. Any symbols lying outside of the new bounds will be deleted, whereas new cells will be empty.

Similar to the grid format the row format will display the pattern rows, but will forego the representation of the columns. Instead the cells of a row will be summarized in such a way, that consecutive, identical symbols will be represented by a number value equal to the count of the symbols and followed by the stitch symbol. Rows in this format can be edited like a conventional text editor - a movable cursor to show where further user input will be inserted and text selection functions for multiple character deletion, copying and pasting will be available. The software keyboard corresponding to this format will consist of the stitch symbols and a num pad, as well as an enter and a backspace key.

Viewing a pattern will come with a row counter below the actual chart pattern. This counter can be increased, decreased and reset by utilizing buttons. The current row will be indicated through a highlight on the pattern, marking the corresponding row in both grid and row format.

While editing or viewing a pattern, the row and the grid format will allow the user to 2D scroll, meaning both vertical and horizontal scroll. Additionally, the grid view can be zoomed and reset to default zoom and scroll. Switching between both formats while editing and viewing a pattern will be supported with a button. Upon switching the pattern will be saved. Renaming, deleting, saving, and exporting the pattern will be possible from within both formats with menu entries.

On app launch the list of patterns saved on the device will be shown. While viewing that list menu entries for exporting all patterns and importing a single pattern will be available. For the import the user can choose a file on the device from a file chooser. Exporting will export files to a set directory on the publicly accessible storage of the device. A list item will consist of the pattern name, an edit, and a delete button. A click on the pattern name will open the pattern in the viewer in row format with the default dimensions of 10 columns and 10 rows. Below the list will be a button to create a new pattern which will open a dialog for entering the new pattern's name. After confirming a name, the editor will open with the row format.

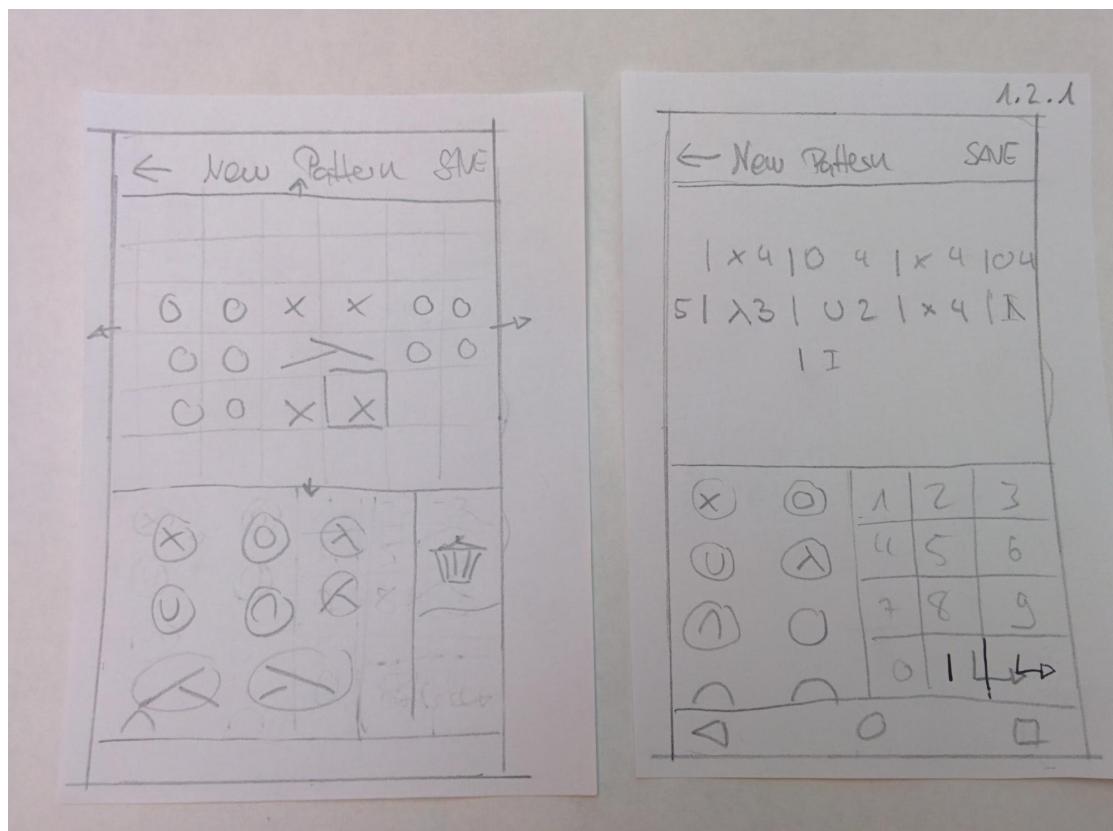


Figure 4.1: Editor screens for grid and row format with pattern name and save button in navigation bar

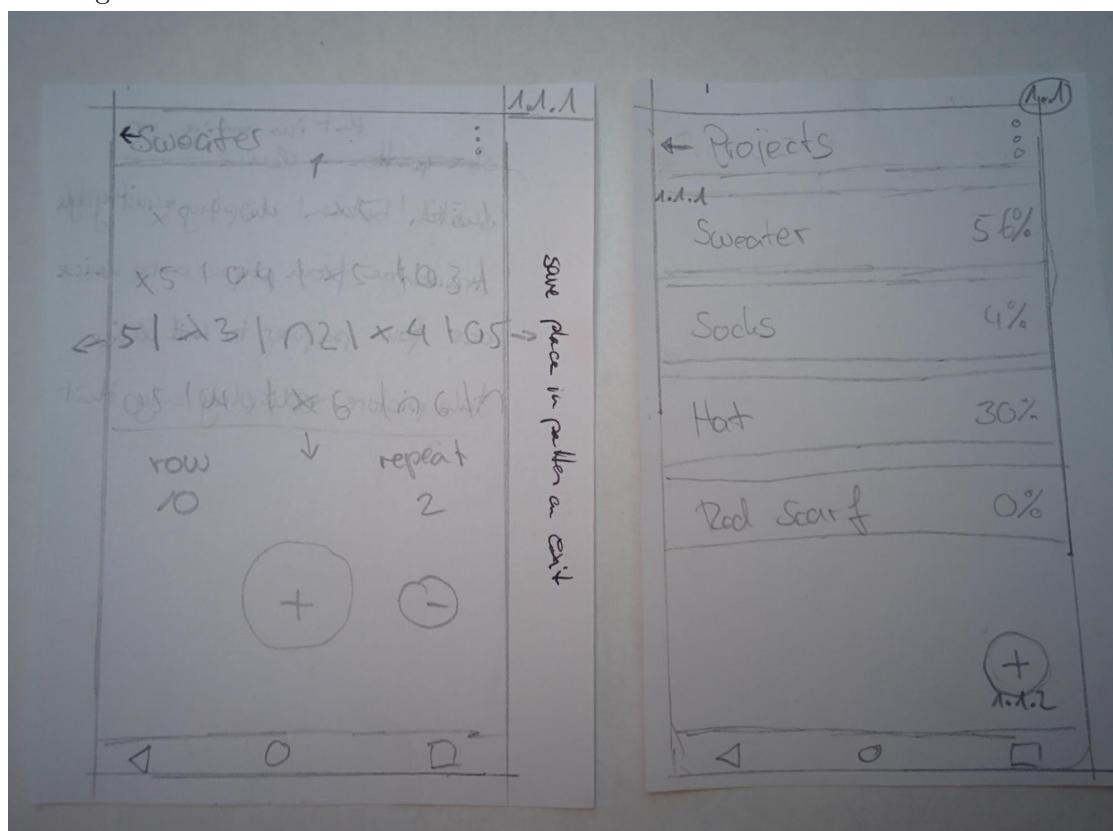


Figure 4.2: Viewer screen for row format and selection screen for stored patterns

Figure 4.3: Screens for editor and viewer without Android elements

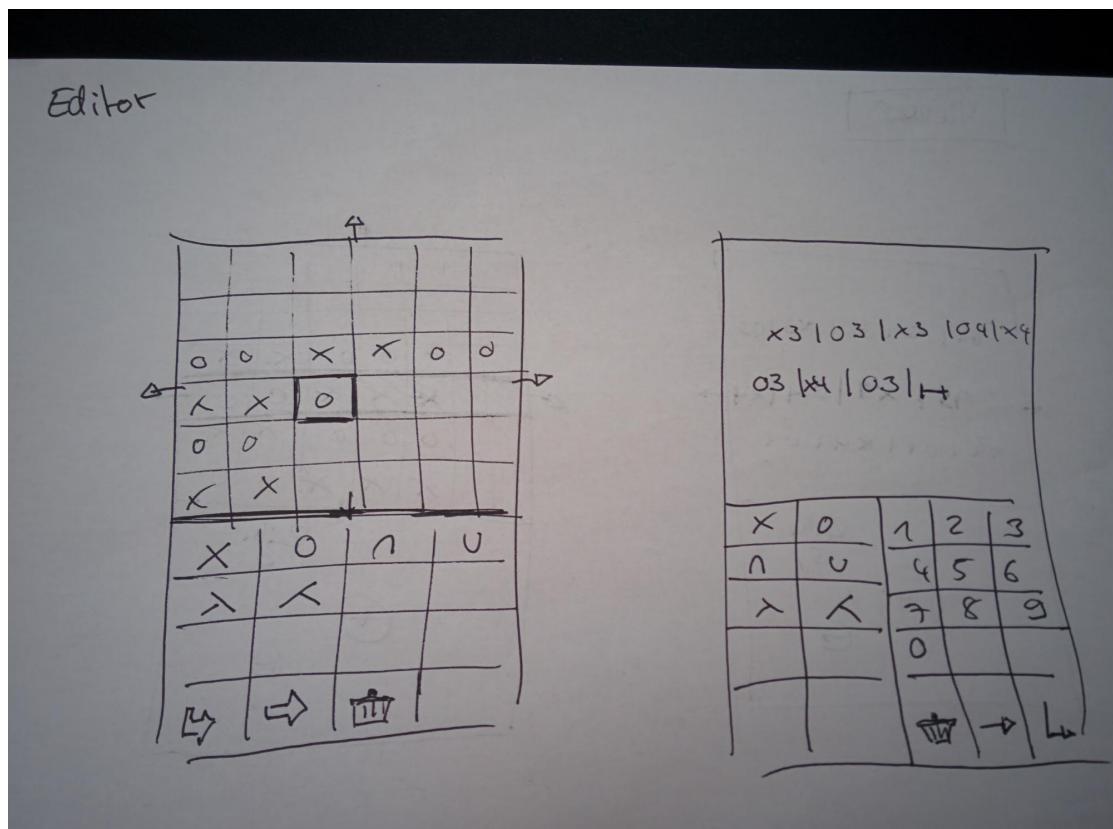


Figure 4.4: Editor screens for grid and row format

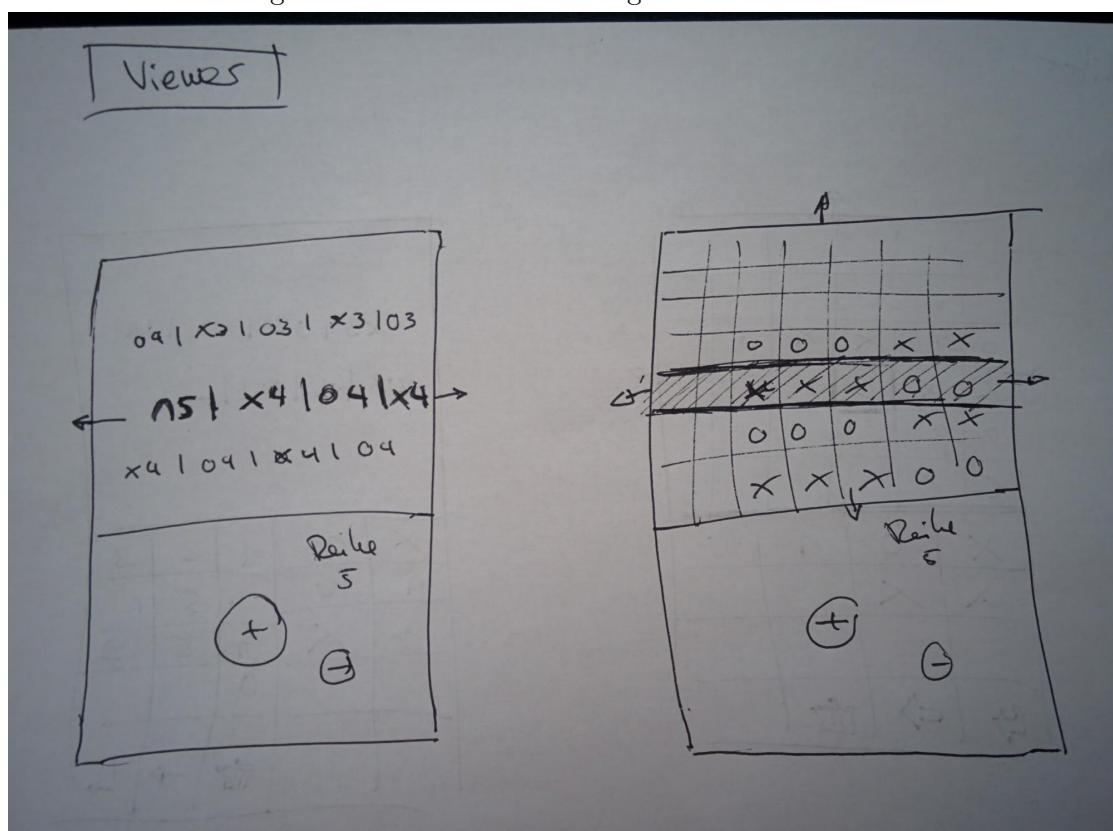


Figure 4.5: Viewer screens for grid and editor format with row counter

Chapter 5

Android Basics

5.1 The Operating System Android

Android is an open source operating system for mobile phones and tablets based on the Linus kernel (Android Developers 2016c). Android apps are distributed on Google Play, a service owned by Google. To build an Android app Google offers the Android Software Development Kit (SDK), containing sample projects, necessary Android libraries and an Android emulator. Additionally, Google recommends to use the official Android Integrated Development Environment (IDE) Android Studio, which is based on IntelliJ IDEA and offers many useful tools, including testing frameworks, a Graphical User Interface (GUI) for screen layouts, and the build tool Gradle (Android Developers 2016h). The concepts and Android components discussed throughout this chapter are taken from the Android Developer reference¹, training², and Application Programming Interface (API) guides³ found online.

5.2 Basic Components of an Android App

5.2.1 Activity

The Activity class is needed to display any user interface and as such usually has a single purpose — handling a login would be such a purpose. An app consists of one or more activities that are in some way connected to each other (Android Developers

¹<https://developer.android.com/reference/packages.html>

²<https://developer.android.com/training/index.html>

³<https://developer.android.com/guide/index.html>

2016b). ViewGroups and Views can be added to the view hierarchy of activities and fragment — these views define different UI components for Android. An activity can also embed multiple fragments which then live in a ViewGroup inside the activity's own view hierarchy (Android Developers 2016g). When containing fragments, the activity's job is that of managing those fragments through getters and setters and orchestrating the communication between fragments, which is done with callbacks defined in the fragments. Activities feature methods such as `onCreate()`, `onStart()`, `onStop()`, and `onFinish()`, which can be overwritten to implement logic that is executed at different points in its life. Same applies for a fragment, but where an activity can stand alone, a fragment always needs to be attached to an activity; it is connected to that activity's lifecycle.

lifecycle
figure

5.2.2 Actionbar

The actionbar located at the top of an app and has several important functions. It displays the application name or the title of an activity, houses the action buttons, and the action overflow. Action buttons should contain the most commonly and important actions used in an app (Android Developers 2016a). The action overflow contains action buttons that are hidden from plain view, either because the actionbar was not wide enough to show all buttons or because of a deliberate design decision. Such a decision is usually made when the button in question is connected to an action that is rarely used, e.g. renaming something, or when the action has far-reaching consequences and shouldn't be near buttons that are used frequently, lest the user accidentally hits it. Such an action could be the deletion of the currently edited pattern, in case of an knitting app.

5.2.3 Fragment

The Fragment class ususally implements a specific user interface or behaviour and should, ideally, be modular, so that they can be reused within multiple activities or in different screen configurations. Just like an activity a fragment has its own lifecycle, see **Figure 5.1**.

A fragment's creation is always embedded in an activity (Android Developers 2016g) — forcing the fragment to pause or stop alongside its parent activity's lifecycle. Fragments can also house viewgroups and views and are intended to function as interchangeable modules, e.g. as UI modules for an app that runs on devices of varying sizes and

that wants to present the user with a dynamic UI fit to suit the screen size (see **Figure 5.2**).

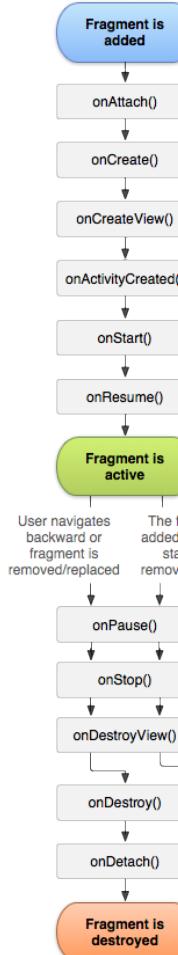


Figure 5.1: The Fragment

life cycle

Android offers different fragment subclasses with predefined behavior, such as the `DialogFragment` class, that opens a fragment as a floating dialog by default (see **Figure ??**). Communication between different fragments needs to be handled by the activity, which manages the fragments. An activity communicates with a fragment by keeping a reference to the fragment and calling its public methods. On the other hand the fragment should not possess a reference to its parent activity — instead the parent activity should implement a callback interface defined inside the fragment (Android Developers 2016f).

add figure
dialog frag-
ment

A good practice to enforce the implementation of a fragments callback interface is to check for its existence when the fragment is attached to the activity — example code proposed by the Android Developer guide concerning how to check for this can be seen in *Listing 5.1* (Android Developers 2016f).

```

1 public static class
2     FragmentA extends ListFragment {
3         OnArticleSelectedListener
4             mListener;
5         ...
6         @Override
7         public
8             void onAttach(Activity activity) {
9                 super.onAttach(activity);
10                try {
11                    mListener
12                        = (OnArticleSelectedListener
13                            ) activity;
14                } catch (ClassCastException
15                    e) {
16                    throw new ClassCastException(activity.toString() + " must
17                        implement
18                        OnArticleSelectedListener
19                        ");
20                }
21            }
22        ...
23    }

```

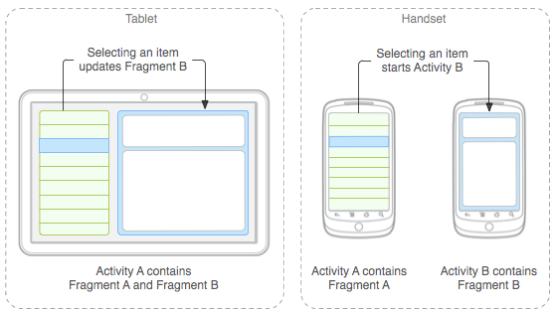


Figure 5.2: Two fragments of one activity and their layout on two different screen sizes

Listing 5.1: Example code for enforcing the implementation of a callback interface

5.2.4 View

Views are the most basic block that the UI is built from (Android Developers 2016l). A view's bounds are always rectangular and its position is defined by its top and left coordinates with the point of origin at the top left. It is the view's job to handle its drawing and event handling. For this the view has the predefined methods `onDraw()` and `onTouchEvent()`, respectively. The view class is also the base for viewgroups which in turn are the base for layouts, containers for other views or viewgroups. The views from

a window are arranged in a tree structure. Views can be added to this tree statically, by specifying them in an Extensible Markup Language (XML) layout file, or dynamically, from code. Android comes with plenty of view subclasses, specialized in acting as controls or displaying specific types of content, e.g. text or images. If the pre-existing views don't match a developer's needs, they can also implement a custom view to take control of the drawing and the event handling as it fits their requirements. For this the `onDraw()` method can be overridden and custom operations can then be executed on the `Canvas` object that is contained in the method parameters.

Android ships with many subclasses of `View`, specialized for displaying text (`TextView`), or a button (`Button`). The `view` class is also the basis for `ViewGroups`, to which the layouts, e.g. `LinearLayout` and `RelativeLayout`, belong to. Views in a window are bundled together as a tree with a layout being the top-most root. To add views to an activity or fragment the views can be declared in the corresponding XML layout or from code.

5.2.5 Storage

File storage in Android devices is separated into “internal” and “external” storage — this refers to the fact, that Android devices often times have a built-in, non-removable memory and an external, removable medium in the form of an SD or a micro SD card (Android Developers 2016e). This storage separation even exists on devices with only built-in memory — in such cases the storage is partitioned into “internal” and “external” partitions. This assures that the concept of two storages persists across all devices and API levels. The internal storage is inaccessible by the user under normal circumstances — exception to that is when the user has root privileges, e.g. on a rooted phone. This storage houses, among other things, files from apps, e.g. databases. These files are only accessible by the app that originally places them in the internal storage — neither user nor other apps can access them. Files are removed when the app they belong to is uninstalled. The external storage on the other hand is more public. Files placed here can be read and written by user and other apps and they even remain after the app they originated from is uninstalled. When working with the external storage it is important to check that it is not currently used as Universal Serial Bus (USB) storage by a computer the device is connected to. Apps have by default read and write access to the directory they are installed in on the internal storage, but to access the external storage the app requires that the user grants the app a specific permission. This permission needs to

be declared in the app's manifest file, a XML file that every app must have. This file contains information required by the Android system to allow the app to run, such as the activities contained in the app and the permissions the app requires. Beginning in Android 6.0 (API level 23) apps targeting that Andoir version need to request and aquire dangerous permissions at run time (Android Developers 2016j), whereas before the app was given all permissions listed in its manifest upon agreeing to a dialog popup when installing the app. Dangerous permissions cover access to the user's private data or to affect areas where the user stores their data or data that other belong to other apps (Android Developers 2016j). Since the user can revoke permissions for apps at any given time the developer needs to take measures to keep the app running even when some features need to be disabled because of missing permissions.

Chapter 6

Implementation

Google’s IDE Android Studio 2.1.2 was used for the implementation of the Android app prototype.

The prototype targets Android 6.0 Marshmallow (API level 23).

6.1 Stitch symbols

There are different ways to display a stitch symbol in an Android app — this section will give an overview of the possibilities and the solution chosen for the prototype. Since the View class already defines a canvas object with dedicated functions for drawing image and text content in its `onDraw()` method, it offers a good starting point. To decide between using the image or text format for displaying stitch symbols, a further look into what each format entails is necessary. Using image resources

Image content needs to be specified in an Android project in the `res` directory under the `drawable` directory. This directory contains the image resources of the app, the `drawables` — this applies for icons, custom images, and other image content, exempting the launcher icon of the app, which is located in the `mipmap` directory. One way to use stitch symbols in an Android app would be to add every symbol as a drawable resource, and then draw those resources to the canvas of a view. For this a drawable would be needed for each individual stitch symbol, as well as a way to map these drawable files to values that can be efficiently stored in a JSON file. The usage of many drawables in an app would also lead to an increase in app size, resulting in longer download times and

larger storage demands. Both are an inconvenience to the user and can be problematic on older devices with less powerful hardware, making the app unusable in the worst case scenario. The other option for displaying symbols is to create a custom True Type Font (TTF) with glyphs for stitch symbols that is applied to text in the app. This is the solution used in the prototype. It offers several advantages over using image resources. For one, when using drawables it might be necessary to include several versions of the same file to assure that they are displayed correctly on devices with different screen densities (**android:densities**). This is not needed for text with a custom font: the glyphs are defined by Beziér curves, which are correctly rendered by the system for the individual screen densities. The usage of a font also allows to write each stitch as a characters, simplifying the process of saving a pattern to a JSON file. For OpenType fonts, which TTF belongs to, Microsoft recommends 64000 as the maximum number of glyphs a font should contain (Microsoft Corporation 2014). This allows for a plethora of stitch symbols. The open source program FontForge¹ was used creation of the custom TTF knitting font used in the prototype. The knitting font contains a selection of 16 stitch symbols whose glyphs were defined by the author herself. The glyphs and their corresponding UTF-8 characters can be found in the Appendix A: . The available symbols the knitting font offers as well as the corresponding symbol descriptions need to be defined as a inside string arrays in the Constants class in the project.

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ref here!

6.2 Pattern and Parsing between Pattern Formats

Using a custom font for the stitch symbols allows for presenting patterns as a combinations of characters. The actual pattern chart is saved to a JSON file as an Array of Strings, where each String represents one row in the chart. For this a Pattern Plain Old Java Object (POJO) is used. It contains fields for the number of columns and rows, the current row set in the counter, and an array of strings, where each string represents a row in the pattern. A pattern object's default state after initialization contains a pattern of the size 10 x 10 cells that is filled with the string representing an empty stitch — an empty stitch is represented by “Z” in the prototype. The class Pattern is a subclass of Metadata.java, a class containing fields for a pattern name and a Universally Unique Identifier (UUID). More about the Metadata class can be found in 6.3.

¹<https://fontforge.github.io/en-US/> (last accessed: 08-10-2016)

The pattern in the Pattern POJO is saved in the shortened row notation. To display the pattern in the grid and row format, the pattern needs to be parsed into forms that are usable by both formats. For that the class PatternParser.java is used. It converts between the array of strings used in the Pattern POJO, a two-dimensional array of strings used in the PatternGridView (6.4.1), and a single string with linefeeds used in the row format's Edittext widget (6.4.2). For a more detailed explanation of the pattern notation forms refer to the corresponding sections.

6.3 Persistent Disk Storage

There are multiple ways persistent storage can be implemented in Android. A common choice is to use a SQLite database, which Android natively supports (Android Developers 2016i). Another choice is to save data in files. The prototype implements the latter, since it reduces the export of files to a simple matter of copying to a different directory. Therefore, instead of using a database, the prototype saves JSON files to the disk. This can be done either in internal or external storage, as explained in 5.2.5. Since permanent accessibility of files cannot be ensured for files located on the external storage, the pattern files are saved in internal storage, in the default directory that Android allocates for the app, and are exported to the user-accessible external storage.

For this a Pattern POJO is serialized using Google's JSON library Gson, which handles the marshalling and unmarshalling of the files to Java objects and vice versa. Gson supports the usage of Java generics and can map JSON data to POJOs while maintaining inheritance hierarchies. [The corresponding code can be found in the class PatternStorage.java.](#)

cite
here

ref here

The Pattern class inherits from the class Metadata which contains both a UUID which is used as a pattern's file name and the pattern name that is given by the user. When storing on disk, Pattern POJOs are converted to JSON using Gson and saved with the UUID as filename. Before that the metadata of the pattern is added to a local ArrayList of Metadatas in the PatternStorage class. This ArrayList in turn is marshalled to JSON and saved to the same directory as the pattern files. It acts as an index of all patterns saved on the device. Using this index file increases performance, since not all pattern files, with their potentially big pattern data, have to be accessed and unmarshalled — instead only the lightweight metadata files need to be loaded. Individual pattern can then be loaded using the UUID saved in the patterns Metadata.

6.4 Displaying a Pattern

6.4.1 Grid Format

When considering presenting data in a grid format, the most obvious solution is to first look at Android's own implementations of grids. Promising starting points for that are the `TableLayout` and the `GridView` class. After a brief investigation into the `TableLayout`, it quickly becomes apparent, that this layout is intended more as a way to position views, than to represent data in a grid. It can be likened to the HTML table tag (Android Developers 2016k), which is also used to position views within the constraints of cells, columns, and rows.

Android's `GridView` class, on the other hand, is designed with notion of displaying data. Each cell represents one data entry in a collection of data, the displaying of which is handled by an `Adapter` class attached to the grid view. Android ships with a specialized adapter for lists², as well as a `BaseAdapter` that can be subclassed for a custom handling and presentation of data. While this is a fitting solution for displaying symbols in a grid, it does not meet the requirements this project sets for the grid format. It is required that the column and row numbers are displayed next to the grid as axes. These axes should scale and scroll together with the grid, but should not be scrolled outside the visible area, since the user would not be able to know the cell position then. For one, the `GridView` class does not support frozen cells, columns, or rows — as far as the author of this thesis was able to research. If the column numbers were to be displayed in the first row of the grid, they would move offscreen upon scrolling the grid. A possible solution to this would be to use text views to act as axes to the grid and to display the column and row numbers next to it. Problematic with this approach would be the fine-tuning required to match the visuals of the text view to that of the grid. Line height, text size and the synchronization with scrolls and zooms performed on the grid would need to match perfectly. Since this does not classify as intended behavior for these views, a cohesive UI cannot be guaranteed. Furthermore, Android does not offer two dimensional scroll on any view except its `WebView`³ – the `GridView` class natively only supports vertical scroll.

²<https://developer.android.com/reference/android/widget/ListAdapter.html> (accessed: 11-08-2016)

³<https://developer.android.com/reference/android/webkit/WebView.html> (accessed: 11-08-2016)

Therefore, in order to fulfill all requirements it makes the most sense to create a custom implementation of a view that supports the display of text in a grid, two-dimensional scroll, zoom, and axes that stick to the view bounds. Google's sample project *Interactive Chart*⁴ and the corresponding training path⁵ present an implementation example and were used as a guide line for the implementation of the class PatternGridView.java . This class keeps a reference to a two-dimensional array of strings which represents the pattern with its columns and rows. The grid and its axes are drawn by overriding the onDraw() method, calculating the position of the corresponding lines and numbers with the dimensions of the view and pre-defined, hardcoded values for cell width and margin. The current version of the PatternGridView uses a SimpleOnGestureListener to compute two-dimensional dragging. Android defines two different scrolling types for views: dragging and flinging (Android Developers 2016d). Dragging is executed by dragging a finger across the device's touchscreen and results in a moving of the view corresponding to the dragging direction and speed. This means, that no matter the velocity of the dragging gesture, the view won't keep moving once the user lifts the finger involved in the gesture. A fling on the other hand will keep moving the view with a speed and duration exponential to the velocity of the fling gesture, where the duration is calculated by introducing a friction to the scroll. This gesture can also be described as a swiping motion performed on the touchscreen. Even after the finger has been lifted off the screen the fling continues to execute until it either runs its course or is interrupted.

The current version of the PatternGridView implements a simple dragging gesture and does not support flinging as of yet. For this a variable of type Point is saved locally to represent the offset scrolled. It is initialized with the value (0,0) and updated on every motion event that is recognized as dragging. The necessary calculations for these updates are done by overriding the onSCroll() method in a custom SimpleOnGestureListener. This method has access to the horizontal and vertical distance scrolled, which is subtracted from the offset. This is done because the value of the distance is positive when dragging towards the point of origin (the top left corner) and negative when dragging away from it. Therefore, the canvas needs to be translated in the opposite distance. The offset is then clamped to minimum and maximum values, to ensure that the grid will never completely move offscreen:

⁴<https://developer.android.com/shareables/training/InteractiveChart.zip> (accessed: 11-08-2016) A digital copy of this project can also be found on the CD attached to this thesis.

⁵<https://developer.android.com/training/gestures/scale.html#drag> (accessed: 11-08-2016)

reference here

code example
2d array
to show
columns
and
rows

ref here

ref docs
point
class

ref

$$offset_{min} = (0, 0)$$

$$offset_{max} = (width_{view} - width_{content} - 2 * margin, height_{view} - height_{content} - 2 * margin)$$

where margin is the distance of the grid from the top and left view edges that is reserved for the axes text.

Similarly to dragging, scaling is implemented with a SimpleOnScaleGestureListener with is connected to the view's onTouchEvent(). The scaling factor is then clamped at pre-defined maximum and minimum values and saved in a variable. During the drawing operations of the grid, axes, and text the scaling factor is then used to compute and draw the scaled visuals. On user touch on the grid the touched cell is calculated from the pixel position of the touch event and the currently selected stitch string is saved to that position in the two-dimensional pattern array. Following this the view is invalidated and re-drawn with updated pattern.

[ref here](#)

[ref to method in docs here](#)

6.4.2 Row Format

requirements: editor should have standard text editor functionalities: copy, paste, cut, select, multi lines, scrollable horizontally and zoom problem: texteditor has standard functions (cut, copy, select, paste) also has multi lines as well as horizontal scroll but doesn't support multi line and hori scroll at the same time if scroll, then only single line if multi line, then vertical scroll and wrap at the end of the screen, no content outside of visible area edittext default opens soft keyboard solving attempts: using custom edittext to suppress opening of soft keyboard create custom edittext override ondraw for drawing line numbers implement custom scroll zoom only scaled the canvas, but not the text realize now: shouhld have set text size, then it would have scaled correctly use library twoDScrollView as parent view to standard edittext only supports on child touch events got mixed up? use linear layout with custom scroll put textview for line numbers inside put edittext inside next to textview calculate container width from edittext calculation often times wrong trying to scroll to cursor when typing goes wrong at end of line: edittext still calculates new cursor position in next line from default wrapping behavior when adding line at bottom: should scroll new line so that is visible:

not working, edittext doesn't now new height before drawing also problem upon fragment first showing: edittext doesn't now how many lines it has upon instantiation with text can't set container height and can't set line numbers can't scroll in viewer, can only scroll in editor after editing something as the edittext then updates and knows its height

6.5 Keyboard

The row and the grid editor each use different symbol keyboards. The keys of the grid editor keyboard feature stitch symbols and a delete button. Keys can be toggled to an active state — only one key at a time can be active. While a key is active, touching the grid will lead to the string corresponding with the active key being added to the pattern at the location of the touched cell. Since empty cells contain the designated empty character “Z”, deletion works in the same way as setting a symbol on the grid. The keyboard is implemented using a Gridview⁶, a default Android component to display a collection of items in a grid with equal spacing between all items. The gridview also by default supports vertical scrolling. A grid item consists of text set on a button of the class KnittingFontButton, a custom class extending Android’s own Button widget. The custom button sets the knitting font to display its string title as a knitting symbol. Set on the button are a click listener and a long click listener. The click listener toggles the state of the key and on long click the description of the symbol displayed on the button is shown at the bottom of the screen.

refer to
symbol
chart
here

In the row editor the keyboard is divided in three sections. One section contains the stitch symbols, one a number pad and one an enter and a backspace button. Pressing a key on either number pad or symbols section appends the corresponding string or number to the editor at the current position of the cursor. The enter and backspace button call the system’s enter and backspace key events from Android’s software keyboard and do therefore not require custom handling, but only to be forwarded to the editor.

The symbols section is also a Gridview, although with less columns than in the grid editor. The numpad uses the CalculatorPadLayout from Rahul Parsani’s Material Calculator project⁷. The CalculatorPadLayout takes a number of child views, in this case KnittingFontButtons, as well as arguments for row and column count. It then calculates the size of the child views, so that all are equal in size. This custom layout is

⁶<https://developer.android.com/reference/android/widget/GridView.html>

⁷<https://github.com/rahulparsani/material-calculator>

used because it optimally arranges its children in the available space without scrolling. A Gridview, on the other hand, is built to dynamically accommodate data and possible data changes — it is only concerned with the number of columns the data views can be placed in, if the Gridview bounds are too small to display all rows they will automatically be placed offscreen and the Gridview will become scrollable — an undesired and atypical behaviour for a number pad, in the author's opinion.

6.6 Viewer with Row Counter

The row counter and the viewer are implemented in the `ViewerActivity` class. The activity's layout file defines a container `FrameLayout`⁸ for the pattern content and below that the row counter UI. On its creation the activity instantiates a `PatternGridView` and a `RowEditorLinearLayout` and sets the data of the viewed pattern on both. The view and the layout can then be switched out at runtime inside their container by adding and removing the required view whenever the user decides to switch between grid and row format. At the current version of the prototype the row format is still experiencing some issues: the line numbers are not correctly instantiated and the pattern, if larger than the screen, is not scrollable inside the viewer.

source
code ref
here

The row counter below the pattern features a display the current row number the user is at in the knitting pattern and two buttons: one for increasing the counter and one for decreasing. The current row is set on both pattern format views as well, but only indicated with a visual highlight in the grid format. The grid format also scrolls the current row into view whenever an increase or decrease happens and the current row is offscreen.

The actionbar contains the following action buttons

- Switch pattern formats
- Open glossary
- Scroll to current row
- Export pattern
- Reset row counter

⁸<https://developer.android.com/reference/android/widget/FrameLayout.html>

- Edit pattern

where the last three buttons are located in the overflow section.

6.7 Editor

The class `EditorActivity.java` contains, just like the `ViewerActivity`, a `FrameLayout` to [ref here](#) programmatically add the grid and row editor fragments to and allow easy switching between the visible fragments. The actionbar contains the following action buttons

- Switch pattern editor formats
- Save
- Set grid size
- Export pattern
- open glossary
- Edit pattern name
- Delete pattern

where the last four buttons can be found in the overflow section. The action button to set the grid size is only shown when the pattern is being edited in the grid format.

Upon switching the pattern formats changes to the pattern are automatically saved and upon success a short message is shown to the user. Then the user tries to exit the editor while there are still unsaved changes a dialog is shown offering the user to save the changes or to discard them and close the editor. After a pattern is exported an info dialog is displayed the directory on the external storage that the file was exported to. The activity also handles the showing of dialog fragments to request user input and processes the results. The dialogs handled in the `EditorActivity` are the `GridSizeDialogFragment`, [ref](#) the `PatternDeleteDialogFragment`, and the `PatternNameDialogFragment`. [ref](#) [ref](#)

6.7.1 Editor Fragments

Each of the two editor formats has its own fragment that displays the for that format appropriate keyboard. The fragments handle the saving, loading, and updating of the pattern data as well as the keyboard events. The grid format fragment also displays the dialog for changing the grid size.

6.8 Pattern List

The prototype launches with the `PatternListActivity` that displays all files currently indexed in the `Metadata` file (see 6.3). For that Android's `ListView`⁹ component is used. For each file the pattern name, a button to edit (pencil icon), and a button to delete (trash can icon) the pattern are shown. The edit button opens the selected pattern in the `EditorActivity` and the upon delete the `PatternDeleteDialogFragment` is shown.

6.9 Glossary

Like the `PatternListActivity`, the `GlossaryActivity` also uses a `ListView`¹⁰ to display the symbols and their descriptions. The symbols and their descriptions are taken from the `Constants` class.

⁹<https://developer.android.com/reference/android/widget/ListView.html>

¹⁰see footnote 9

Chapter 7

User Test

After the implementation of a working prototype in accordance with the requirements set at the beginning of this thesis, the interview participants were invited to test the prototype. One participant had no experience nor interest in using knitting pattern charts and was therefore not included in the prototype test. The participants were asked to execute tasks derived from the requirements inside the prototype app during which their reactions were observed, with the main goal of determining the usability of the two pattern chart formats. After the completion of the tasks the user's feedback concerning the prototype was discussed. Users were asked to note whether the prototype met the expectations they expressed during the interview and whether it failed to do so. The users were also asked to judge the overall usability — the ease of use of the features, as well as the unambiguousness of the user interface. All user tests were held separately without communication between the participants. The results of these user tests are summarized in the following paragraphs.

Both participants were able to create and name a new pattern without problems. When first confronted with the default pattern in the row editor both expressed initial confusion about the shortened row format. After a brief explanation on what the number and symbol combination signified in the row format and how it would be displayed expanded when viewed in the grid format both participants were quickly able to work with the row editor and accurately produce results they were aiming for. For this they at first relied on switching to the grid editor to see how their changes in the row editor would play out — they were only able to grasp entirely how the row editor functioned after seeing the changes they did to the pattern in the expanded grid format. The participants

did not expect the editor to support the standard editor functionalities such as selecting, copying, cutting and pasting text. Both participants had problems when asked for the first time to edit the pattern in the grid editor: they expected the same typing behaviour from the symbol keyboard that they encountered in the row editor. It took a few tries and an explanation of the toggling mechanics to enable them to successfully use the grid editor. In both tests the participants found and used the buttons to switch editors and save the pattern without problems. The same holds true for the menu entries to rename and delete the pattern currently open in the editor. At the time of testing viewing the pattern in row format still had some bugs: larger patterns were not scrollable and the current row would not be highlighted upon increase or decrease of the row counter. The testing of the row viewer will there be disregarded for this user test iteration. All functions of the row counter and the grid viewer were used and understood by both participants from the start.

Following the instructed testing the participants were asked to express their feedback concerning the prototype. Both participants expressed the desire to see a tutorial or introduction to the formats upon first use of the app since it was not clear from the beginning that there were two formats available to present a pattern chart. After being confronted with the row format on opening a pattern in the editor, the participants expected the grid editor keyboard to behave like the one found in the row editor. They had problems understanding how to use the toggle symbols in the grid editor keyboard and were confused why nothing happened when they touched the grid. For the wish to have a symbol pre-selected was voiced, to indicate that symbols have to be selected to be set on the grid and to help the user understand that touching a cell leads to the selected symbol being set to that cell. One user also mentioned that the trash can icon for the button designed to erase a cell was misleading, they expected the button to delete the whole pattern — an eraser icon would be better suited. Another problem was the missing background behind the line numbers in the grid editor, when the grid was scrolled it was hard to read the numbers. To improve this a solid background should be added to the line number sections.

The row viewer did not fulfill the participants' expectation at all — both agreed that at the very least the pattern needs to be scrollable and the current row should be indicated. The wish to set the current row in the viewer by tapping the current row number in the counter section was also expressed.

The participants agreed that the prototype met the expectations set by the preliminary interviews, excepting the row viewer. They compared the process of creating, editing and viewing a pattern chart to their current methods, modifying a spreadsheet to take the form of a knitting pattern chart, and found the prototype to be much easier and efficient to use. They deemed the ability to edit and view a pattern in two formats very valuable, since same stitch repetitions could be quickly entered in the row format without the hassle of entering every stitch individually in the grid editor. The grid editor offered the ability to easily view the whole pattern and to spot and correct mistakes in it, as well as input more varied stitches in a pattern. Both participants preferred the prototype to their current pattern editors and viewers. One participant expressed the wish for a prototype supporting the same functions with colors instead of stitch symbols for the creation and viewing of colored pattern charts.

Chapter 8

Evaluation and Discussion

requirements reached: yes, except row format ui

- as is state:
- patter file can be imported
- pattern file can be exported to set directory from viewer and editor
- pattern can be renamed from inside editor
- export directory cannot be set by user
- all patterns can be exported for backup purposes
- pattern can be created, edited, viewed, saved, deleted
- row counter exists and is connected to pattern and persisted
- current row in viewer is highlighted in grid viewer
- success and error messages are not completely implemented: save, delete, rename, export, import

known bugs:

- pattern title has no limit
- imported files aren't checked for tile type, cause crash

- row format is a mess
- pattern title not visible: too many action buttons in actionBar
- should start with grid format instead of row
- upon exiting the editor with agreeing to save to unsaved changes no snackbar is shown to user upon successful save
- pattern delete does not show success message
- no error messages yet

Issues:

- Edittext not intended for 2D scrolling -; solutions: add custom scroller to edittext or place edittext in scrollable layout or add custom scroller to layout and place edittext in it
- Canvas in grid lags: onDraw naive implementation -; change implementation to only draw what is visible
- Edittext opens softkeyboard: suppressing is awkward and not intended -; used edittext lib that suppresses behavior programmatically as best as possible, declare soft keyboard state in manifest, then admit defeat
- Row editor doesn't scale -; implement custom on scale gesture listener and scale edittext and textView and container layout accordingly
- Disk operations do not block UI -; add spinner to indicate disk operations, are very fast tho
- Edittext doesn't read line number correctly -; figure out lifecycle of edittext and read line numbers at appropriate time
- Edittext sets width incorrectly -; edittext is not intended to support multiline text that extends beyond screen. wrestle with edittext implementation to try to solve this?
- Orientation change not supported yet -; support is with persistent fragment state = fragments wont be recreated on orientation change

- Different screen sizes not supported -; create xml files for different device sizes

edittext issues:

- could write own editor, but did not because time was short and implementing own solution for selecting text, cutting, copying, deletion, etc typical text editor functionalities was deemed too much effort when there already is a working text editor view which is standard for text editing on android.
- The surprise shown by the participants of the user test may indicate that the standard text editor functionalities — selecting, cutting, copying and pasting text — are helpful features, but not necessary in a knitting pattern row editor. This would allow for a custom built editor better suited for the horizontally scrollable multi-line text used in the row editor that foregoes those functions.

Chapter 9

Outlook

Outlook:

- Ligatures and multi character stitches
- Pictures
- Panning in grid editor
- Support of bigger dimension with canvas optimization
- support of stitches that are wider than one cell
- Focal point when scaling
- built in functions for sharing patterns: email, dropbox, etc
- repeat counter next to row counter for repeated patterns with highlighting functionality for repeats

hello glossary should be here):

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- *Activities*. URL: <https://developer.android.com/guide/components/activities.html> (visited on 08/09/2016).
 - *Android, the world's most popular mobile platform*. URL: <https://developer.android.com/about/android.html> (visited on 08/09/2016).
 - *Animating a Scroll Gesture*. URL: <https://developer.android.com/training/gestures/scroll.html#term> (visited on 08/09/2016).
 - *Choose Internal or External Storage*. URL: <https://developer.android.com/training/basics/data-storage/files.html#InternalVsExternalStorage> (visited on 08/09/2016).
 - *Creating event callbacks to the activity*. URL: <https://developer.android.com/guide/components/fragments.html#EventCallbacks> (visited on 08/09/2016).
 - *Fragments*. URL: <https://developer.android.com/guide/components/fragments.html> (visited on 08/09/2016).
 - *Meet Android Studio*. URL: <https://developer.android.com/studio/intro/index.html> (visited on 08/09/2016).
 - *Saving Data*. URL: <https://developer.android.com/training/basics/data-storage/index.html> (visited on 08/09/2016).
 - *System Permissions*. URL: <https://developer.android.com/guide/topics/security/permissions.html#normal-dangerous> (visited on 08/09/2016).
 - *Table*. URL: <https://developer.android.com/guide/topics/ui/layout/grid.html> (visited on 08/09/2016).
 - *View*. URL: <https://developer.android.com/reference/android/view/View.html> (visited on 08/09/2016).

- Association, Japan Knitting Certificate. *JIS L 0201-1995: Letter symbols for knitting stitch. Standard booklet.* Nov. 1995. URL: <http://www.webstore.jsa.or.jp/webstore/Com/FlowControl.jsp?lang=en&bunsyoId=JIS+L+0201%3A1995&dantaiCd=JIS&status=1&pageNo=0> (visited on 04/04/2016).
- Lewis, Perri. *Pride in the wool: the rise of knitting.* July 6, 2011. URL: <https://www.theguardian.com/lifeandstyle/2011/jul/06/wool-rise-knitting> (visited on 08/09/2016).
- Microsoft Corporation. *Recommendations for OpenType Fonts.* May 1, 2014. URL: <https://www.microsoft.com/typography/otspec/recom.htm> (visited on 08/09/2016).
- Natter, Maria. *Stricken.* Niedernhausen: Falken Verlag, 1983.
- Raz, Samuel. *Flat Knitting Technology.* Heidenheim: Druck Repo Verlag, 1993.
- Whitall, Jonathan. *The KnitML User's Guide.* Apr. 25, 2009. URL: <http://www.knitml.com/docs/users-guide.html#d0e246> (visited on 08/09/2016).