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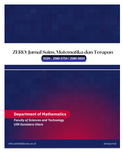

AMBATIG: Android Application for Generating Batik Motifs Using Frieze Symmetry Group Transformations

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ABSTRACT

Indonesian batik is known for its diverse motifs, yet many artisans still design patterns manually, which limits variation and innovation. This study develops Ambatig, an Android application that helps artisans create batik motifs more efficiently. The application was implemented in Android Studio and follows a waterfall development model. Ambatig transforms a user drawn base cell into structured repetitions by composing distance preserving transformations, namely translation, vertical reflection, horizontal reflection, half turn rotation of 180 degrees, and glide reflection. These operations are configured according to the seven frieze types introduced in the study. Functional black box testing confirmed stable performance with all scenarios passing. Compared with previous motif generation approaches, Ambatig introduces a parameterized on device frieze transformation pipeline that produces all seven symmetry families from a single base motif. Real time preview and export features support creative exploration while maintaining mathematical coherence in digital batik design.

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1. INTRODUCTION

Batik is a significant cultural icon in Indonesia. According to its history, the word "batik" is a mixture of two Javanese words: amba, which means "wide" and nithik, which means "to make a point". The term batik then evolved to signify joining dots to produce a specific image on a broad or wide cloth. In the Kamus Besar Bahasa Indonesia (Big Indonesian Dictionary), "batik" is defined as a pictorial cloth made specifically by writing or applying wax to the cloth, which is then processed through a certain process. So, it can be concluded that "batik" can refer to a process as well as the finished (material) result of that process [1]. Batik, which was written and painted on palm leaves, has been around since the 16th century. At the time, animal and plant shapes dominated batik motifs or patterns. Batik has evolved with the times, incorporating abstract themes such as clouds, temple reliefs, wayang beber, and so on. Then, by combining painting patterns with the craft of clothing decoration, the art of written batik as it is known today was born [2].

UNESCO classified batik as a Masterpiece of the Oral and Intangible Heritage of Humanity on October 2, 2009, which strengthened global visibility [3]. At the national level, the Ministry of Home Affairs issued a circular that encourages the use of batik on National Batik Day, reinforcing everyday cultural presence [4]. Despite this recognition, production and export indicators declined in several periods [5]. These conditions underline the need for solutions that help artisans sustain creativity and productivity. From a preservation perspective, prior studies stress that motif development is essential so that batik remains relevant and attractive to younger generations while respecting tradition [6], [7]. Field observations still find many artisans constructing motifs manually and lacking accessible design resources, which limits variation and can create dependence on external design services. This practical gap motivates a computational approach that accelerates exploration of structurally valid motif variants while keeping cultural logic intact.

Aside from the challenges mentioned above, academics are interested in creating mobile applications that can be used to design new themes or develop existing ones. Art activists and academics from several sectors have recently worked on the digital development of batik motifs. The digital technology was chosen since it is thought to be faster than traditional motif processing in making batik motifs. Several prior investigations have also produced motif-creation applications. Wibawanto and Nugrahani [8] developed special software for the creation of batik motifs called D'Batik. This application has been used by small and medium batik industries in Semarang and has an impact on increasing batik productivity. Besides, Barus [9] developed a mobile application named Ditenun. This application can develop ulos motifs based on predefined parameters involving color levels and pattern sizes.

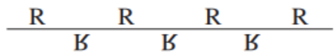
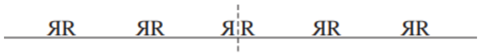
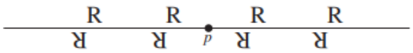
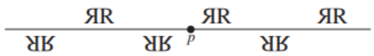
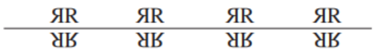
A frieze group is a one dimensional symmetry group generated by distance preserving isometries such as translation, reflection, rotation, and glide reflection, as explained in [10]. Prior mathematical studies have identified the presence of frieze and crystallographic structures in traditional Indonesian textiles, including Malay songket, ulos, and regional batik patterns [11], [12], [13]. However, field observations show that many artisans still design motifs manually and rely on predefined templates, which limits variation and slows creative exploration. In response to this gap, this study formulates three research objectives. The first objective is to design an Android based application that supports free drawing of a user created base cell. The second objective is to implement all seven frieze symmetry types as editable, parameter based transformations that operate directly on a mobile device. The third objective is to evaluate the functionality and mathematical correctness of the system through black box testing and distance preserving validation.

A clearer distinction from previous studies can be seen in terms of implementation and practical use. Works in [11], [12], and [12], [13] focused on analyzing frieze and crystallographic patterns in existing fabrics without transforming the findings into a digital tool for motif creation. Studies in [14], [15], [16], [17] successfully generated motifs using symmetry groups but were limited to Matlab based computer environments, relied on predefined templates, and did not allow free drawing or real time parameter adjustment. The present study offers a different contribution by introducing an Android application that accepts hand drawn input, embeds all seven frieze groups, provides real time preview and parameter control, and exports results directly on the device. This combination of mathematical rigor with mobile accessibility presents a practical innovation that links theoretical symmetry analysis to the everyday design practices of artisans.

More formally, regarding symmetry groups, an isometry of an n-dimensional space $\mathbb{R}^n$ is a function of $\mathbb{R}^n$ on $\mathbb{R}^n$, which preserves distance. Suppose $\mathbb{F}$ is a set of points in $\mathbb{R}^n$. The symmetry group from $\mathbb{F}$ in $\mathbb{R}^n$ is a set of all isometries of $\mathbb{R}^n$, bringing $\mathbb{F}$ to itself with its group operation being the composition function. It is important to understand that the symmetry group of an object depends not only on the object itself but also on the space in which we view it [18]. As is known, each isometry of $\mathbb{R}^2$ is one of the four types: rotation which is the rotation of an object about a certain axis, reflection which is bouncing an object so that each point has a one-to-one mapping to another point that is equidistant from and on opposite sides of the same plane, translation which is a mapping that brings all points the same distance and the same direction, and shear reflection which is the product of translation and reflection across a line that contains the translation line segment. There is an interesting collection of the infinite symmetry group from periodic design of the plane, one of which is the frieze group. The frieze group is a plane symmetry group from patterns in which the translation subgroup is isomorphic to $\mathbb{Z}$. The pattern designs from this group are often used for strip decoration or jewelry [19]. The term group is sometimes referred to as a pattern due to its definition. In the context of motif generation, these mathematical concepts provide a direct framework for transforming a hand drawn base cell into a structured repeating pattern. Each isometry acts as an operation that preserves distances and proportions, ensuring that the motif remains visually consistent after transformation. When these operations are organized into a symmetry group, such as the seven frieze groups, they form a finite set of rules that govern how a motif can repeat along a strip. Ambatig implements these rules by encoding each transformation as a geometric mapping and composing them according to the selected frieze type. This creates a practical realization of abstract group theory, where the user interacts only with drawing tools and parameter sliders while the underlying mathematics guarantees that the generated motif maintains structural coherence and periodicity.

There are seven frieze groups, each a subgroup of the planar isometry group used to produce one dimensional repetitive motifs along a strip. Using x for the basic generator named in each case, and y and z when present, they can be written as follows. Type I uses translation only, so $F_1 = \{x^n | n \in \mathbb{Z}\}$ with x a unit translation to the right. Type II is an unlimited cycle of glide reflection. Suppose x denotes glide reflection, this type can be written as $F_2 = \{x^n | n \in \mathbb{Z}\}$. Type III is the symmetry group generated by translation x and vertical reflection y written as $F_3 = \{x^n y^m | n \in \mathbb{Z}, m = \{0,1\}\}$. Type IV is the symmetry group generated by translation x and rotation 180° y, i.e., $F_4 = \{x^n y^m | n \in \mathbb{Z}, m = \{0,1\}\}$. Type V is the symmetry group $F_5 = \{x^n y^m | n \in \mathbb{Z}, m = \{0,1\}\}$ with x as glide reflection and y as rotation 180°. Type VI is generated from translation x and horizontal reflection y written as $F_6 = \{x^n y^m | n \in \mathbb{Z}, m = \{0,1\}\}$. Meanwhile, type VII is the symmetry group generated by translation x, horizontal reflection y, and vertical reflection z. It is formulated by $F_7 = \{x^n y^m z^k | n \in \mathbb{Z}, m, k \in \{0,1\}\}$, where the product of y and z is rotation 180° [19]. Seven kinds of frieze patterns are shown in Table 1.

Table 1. Seven Patterns of Frieze [18]

Type	Pattern
I	
II	
III	
IV	
V	
VI	
VII	

2. RESEARCH METHOD

The literature review and interviews were employed to acquire data for this investigation. Researchers obtained secondary data from books, journals, and online searches through literature studies. Meanwhile, direct interviews with artisans were conducted to understand the types of motifs they create and the challenges they face in generating pattern variations.

In this study, the mathematical transformation process for generating motifs is implemented using planar isometries expressed in homogeneous coordinates, where each user drawn point is represented as $p = (x, y, 1)^T$. Translation by vector (a, b) uses the matrix $T = \begin{bmatrix} 1 & 0 & a \\ 0 & 1 & b \\ 0 & 0 & 1 \end{bmatrix}$, vertical reflection uses $R_v = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, and horizontal reflection uses $R_h = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, A half turn rotation of 180 degrees is represented by $H = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, while a glide reflection is computed as the composition of reflection and translation using $G = TR_v = \begin{bmatrix} -1 & 0 & a \\ 0 & 1 & b \\ 0 & 0 & 1 \end{bmatrix}$. The frieze groups are constructed by composing these matrices according to their generator structure, for example $T^n, T^n R_v^m, T^n H^m$, or $T^n R_v^m R_h^k$, and the resulting matrix sequences are applied to all points in the base cell to guarantee distance preservation and produce periodic, geometrically consistent motif repetitions.

The waterfall model was used in software development. One of the advancements of the System Development Life Cycle (SDLC) is the waterfall model. SDLC is a model that describes the entire process of developing software by detailing each aspect of how it works [20]. The waterfall model itself is made up of numerous sequential phases that must be completed one after the other and only go on to the next phase (descending like a waterfall) after the previous phase is completely completed. This stage can be repeated indefinitely until the entire procedure is perfect [21]. The different phases of the waterfall model are depicted in Figure 1.

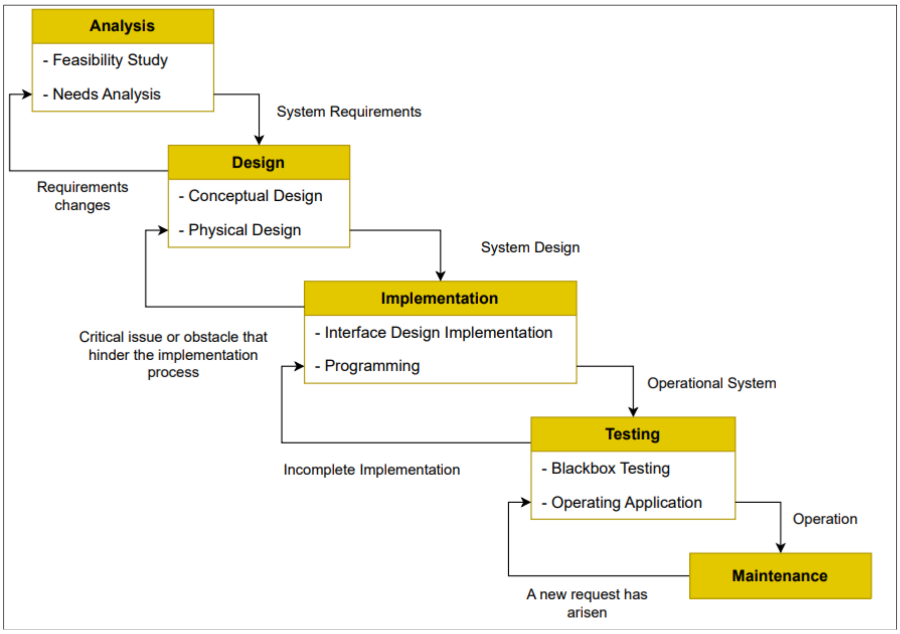


Figure 1. Waterfall Model

a) Analysis
At this point, the researcher examines the software requirements, functions, and procedures of the developed apps. Use cases that explain the user's interaction with the software are used to develop functional requirements. The Software Requirements Specification (SRS) is another name for this level.

b) Design
The researcher creates use case diagrams, entity relationship diagrams, and logical record architectures at this stage. This stage converts software requirements from the needs analysis stage to a design representation that may later be implemented into a program.

c) Implementation
At this point, the researcher transforms the design into a working program that can be executed using programming. This is the stage at which the code is generated and compiled into the mobile application, as well as the database and text files are created.

d) Testing
At this point, the researcher tested the program to determine its weaknesses. For example, determining whether the opening page fits expectations, whether photos and fabric information appear when clicked, whether the frieze patterns that produce motifs are proper, and so on.

e) Maintenance
This is an advanced level in the software development model. For future actions, the researcher will adjust the software to its surroundings, meet the needs of new users, and increase the product's reliability. In addition, user feedback can be submitted through a simple form in the application settings or by electronic mail, and system updates are distributed by signed installer packages from the research team while preserving saved motif files and user preferences.

3. RESULT AND ANALYSIS

This study successfully followed the waterfall model from the analysis stage through testing, and the resulting Android application, Ambatig, provides artisans with a practical tool for generating and developing batik designs. Users may create motifs by drawing freely on the canvas or by modifying existing textile images. The generated motif can be saved directly to the smartphone gallery through the “Simpan” feature. Although the current version is available only in Indonesian, broader adoption is anticipated through future multilingual updates.

Compared with previous studies that generated motifs using symmetry groups in Matlab based interfaces [14], [15], [16], [17], the findings demonstrate clear improvements in accessibility and workflow. Ambatig operates entirely on a mobile device, allowing artisans to design motifs in field settings such as workshops and production sites. The application supports free drawing, so user created base cells can be transformed into structured frieze repetitions rather than relying on predefined templates. It also provides editable parameters for translation size, reflection selection, rotation center, and glide offsets, with real time preview and direct export. These features overcome limitations reported in Matlab based systems and support more flexible, creative, and culturally grounded motif creation.

From a mathematical perspective, the correctness of the generated motifs was verified through a series of computational checks designed to evaluate whether each transformation preserved the geometric properties required by frieze symmetry. For each transformation type, random point pairs in the base cell were sampled and tested to ensure that Euclidean distances remained invariant after the mapping. Given two points p_1 and p_2, the system computes the difference $|p_1 - p_2| = |T(p_1) - T(p_2)|$, and the transformation is accepted only if this difference falls within a floating point tolerance of 10^{-8}. Angle preservation was evaluated by computing the dot product of adjacent polyline segments before and after transformation to confirm that interior angles in user drawn strokes were unchanged. The determinant of the linear component of each transformation matrix was also checked to verify that its magnitude remained equal to one, which confirms that the transformation is an isometry and does not introduce scaling.

To ensure correct implementation of group structure, transformation compositions were validated by comparing the numerical output of sequential mappings with the expected analytical form of the frieze group generators. For example, the system verifies that applying a reflection followed by a rotation yields the same result as applying the combined matrix product. Periodicity was evaluated by checking that consecutive transformed cells align precisely along the translation axis, with no drift or cumulative numeric deviation. Overlap detection algorithms were used to verify that the tiling of the motif does not produce unintended intersections between repeated cells. The system also examines invariance under repeated application of the generator, ensuring that $T^n(p)$ produces consistent spacing for large values of n. These comprehensive checks ensure that the generated patterns conform to the strict structural rules of frieze groups and maintain proportional accuracy, orientation stability, and visual coherence across the entire repeated motif.

The broader impact of this work aligns with current developments in mathematical learning and ethnomathematics education. Digital tools that visualize symmetry and geometric transformations have been shown to strengthen students' conceptual understanding, procedural fluency, and spatial reasoning in geometry classrooms [22], [23], [24], [25]. In ethnomathematics research, cultural artifacts such as batik, ulos, and songket provide meaningful contexts for exploring transformational geometry, proportional reasoning, tessellations, and pattern systems that connect school mathematics to cultural identity and heritage [24], [25]. Ambatig contributes to this direction by providing an accessible mobile platform that integrates symmetry operations, pattern structures, and cultural motifs, making it suitable for use as digital learning media in classrooms, workshops, and community based learning settings. Recent work on mobile assisted geometry learning shows that mobile applications can enhance student engagement and support interactive visualization of mathematical structures [26], [27]. Additionally, culturally embedded digital learning resources have been shown to increase relevance, retention, and appreciation of mathematical concepts among learners by linking mathematics to local traditions and community knowledge [24], [25]. Therefore, beyond its practical utility for artisans, Ambatig offers pedagogical potential as a digital resource that bridges mathematical abstraction with cultural creativity within ethnomathematics education.

3.1. Need Analysis

In this study, the researchers created an Android-based mobile application that users can use offline (without being connected to the internet) for designing creative batik motifs. The criteria for the Ambatig mobile application's demands were broken into two categories: device requirements and system requirements.

a) Device Requirements

1. Hardware: Laptop with an Intel Core i5 or i7 (10th gen or newer) / AMD Ryzen 5 or 7 (4000 series or newer), 16GB RAM, and 512GB SSD or higher (SSD is essential over HDD) and Smartphone with OS Android.
2. Software: Android Studio.

b) System Requirements

1. Page for loading screen;
2. Page to view app features;
3. Pages for painting batik by making your own basic patterns;
4. Pages for painting batik with existing basic patterns;
5. Pages to generate motifs with frieze patterns;
6. Page to see traditional cloth motifs of North Sumatra;
7. Pages to view pictures and information on fabrics based on tribes in North Sumatra.

3.2. Design

In this study, the Ambatig mobile application design used a Unified Modeling Language (UML) diagram which is described into the following stages:

a) Use Case Diagram

Use case diagrams describe typical interactions between users and the system, outlining actors, goals, and main scenarios through a clear narrative of how the system is utilized in practice. [28].

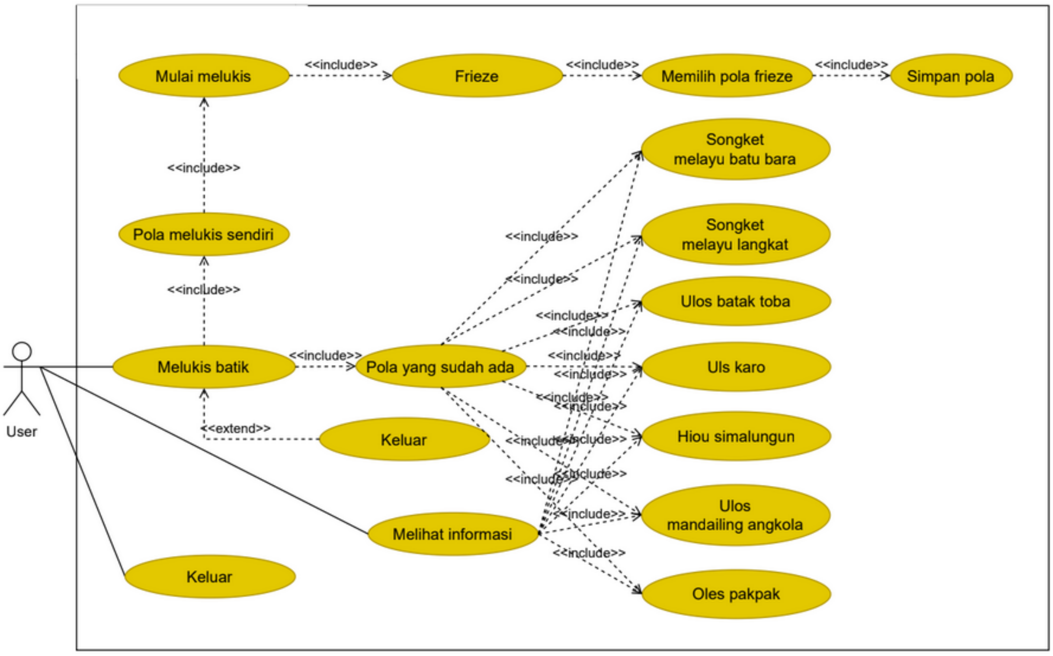


Figure 2. Use Case Diagram of Ambatig

b) Entity Relationship Diagram

Entity relationship diagram (ERD) is a structural diagram used to design a database. An ERD describes the data to be stored in a system and its boundaries. The main components contained in an ERD are entity sets, relationship sets, and also constraints [29].

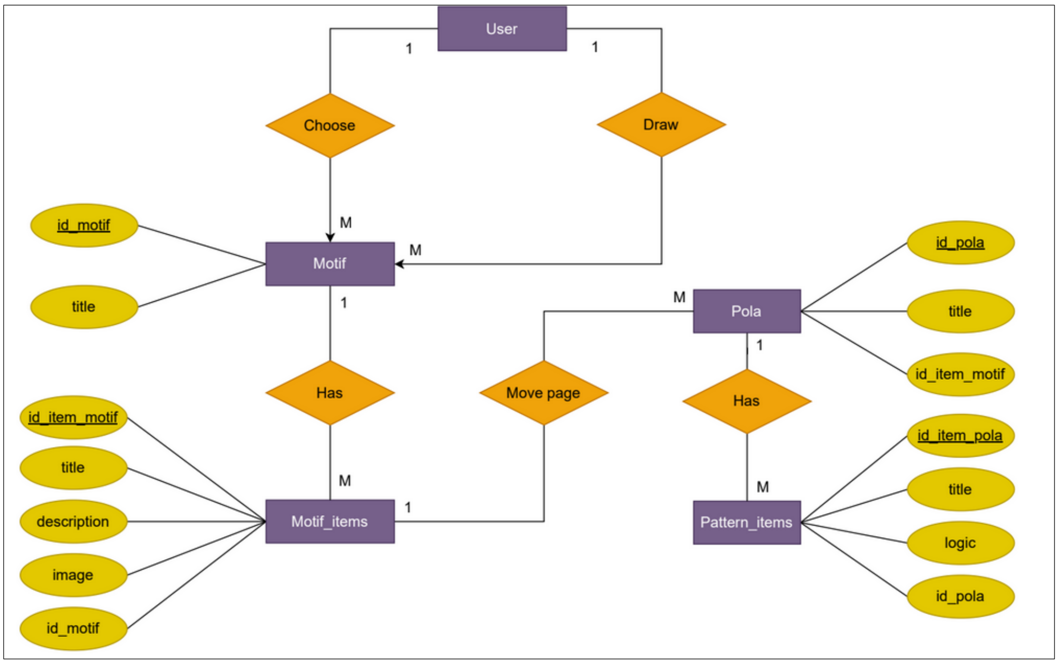


Figure 3. Entity Relationship Diagram of Ambatig

c) Logical Record Structure

Logical record structure (LRS) is a representation of the structure of records in tables formed from the results of the set between entities [30].

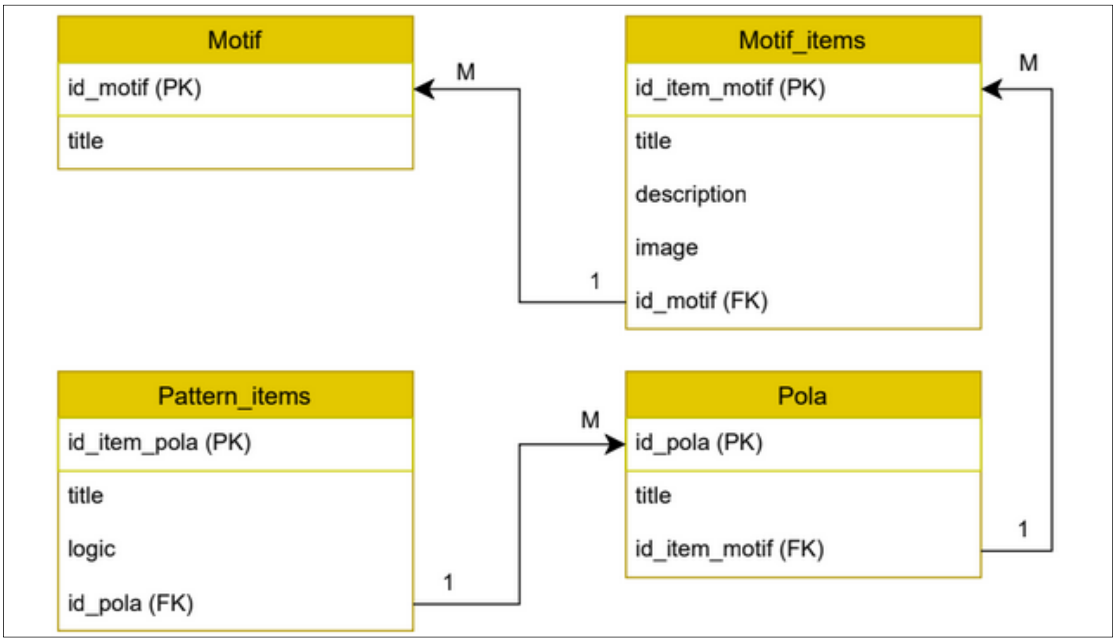


Figure 4. Logical Record Structure of Ambatig

3.3. Interface Design Implementation

a) Display Loading and Front Page

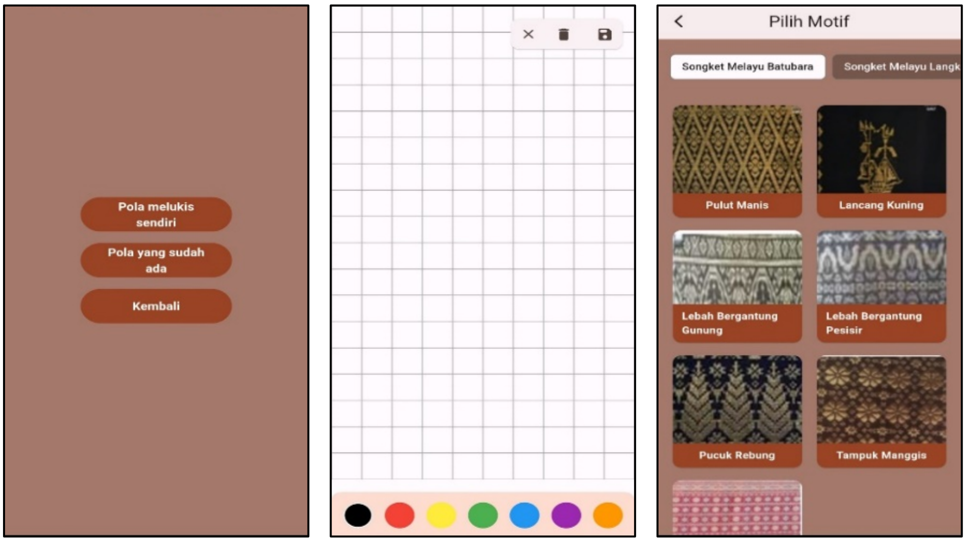
There are three options on the front screen of the Ambatig application: the "Melukis Batik" menu for creating batik motifs, the "Informasi" menu for seeing photographs and explanations of traditional North Sumatran fabrics based on ethnic division, and the "Keluar" button for exiting the application. Figure 5 shows the Ambatig application's front page presentation.

(a) (b)

Figure 5. Display of The Ambatig Application: (a) Loading Screen, (b) Front Page

b) Painting Batik

On the "Melukis Batik" menu, there are two button options, namely "Pola melukis sendiri" and "Pola yang sudah ada", as shown in Figure 6(a). The "Pola melukis sendiri" button, as shown in Figure 6(b), means creating the desired motifs. In this menu, users can draw motifs with various pen color options. There is also a save button and other buttons that can be used when creating motifs. Painting with the "Pola yang sudah ada" button, as shown in Figure 6(c) means modifying existing traditional cloth motifs by adding user creations. There is also an icon for drawing. This cloth motif is taken from the "Informasi" menu on the start page of the Ambatig application.

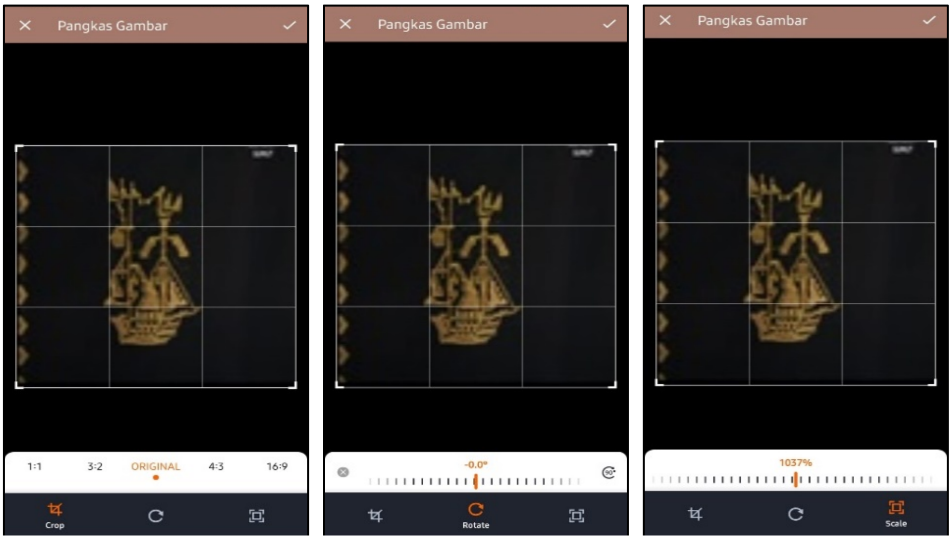


(a) (b) (c)

Figure 6. Painting Batik Menu: (a) Initial Menu Display, (b) Self-Painting Patterns, (c) Existing Patterns

c) Image Crop Menu

The image crop menu contains three options: crop, rotate, and scale. The Crop tool, as shown in Figure 7(a), is used to crop photographs, photos, or canvas (work paper). The Rotate tool, as shown in Figure 7(b), rotates the position of the object according to the user's preferences. The scale tool, as shown in Figure 7(c), allows you to change the scale of the object. Users can carefully customize it to be huge or little. This tool is simple to use; simply point the cursor to the object's corner/point and drag it.



(a) (b) (c)

Figure 7. Image Crop Menu: (a) Crop, (b) Rotate, (c) Scale

d) Information on Traditional Fabrics of North Sumatra

This menu features traditional fabrics from North Sumatra, classified into seven types by ethnic origin and region: Batubara Malay songket, Langkat Malay songket, Toba Batak ulos, uis Karo, hiou Simalungun, ulos Mandailing Angkola, and oles Pakpak. This option assists batik artisans in Medan by providing references drawn from local culture and curated examples for fast visual exploration. Artisans often adapt samples of these textiles to create new motifs and variations during design sessions. Figure 8 shows the Informasi menu for traditional North Sumatran fabrics.

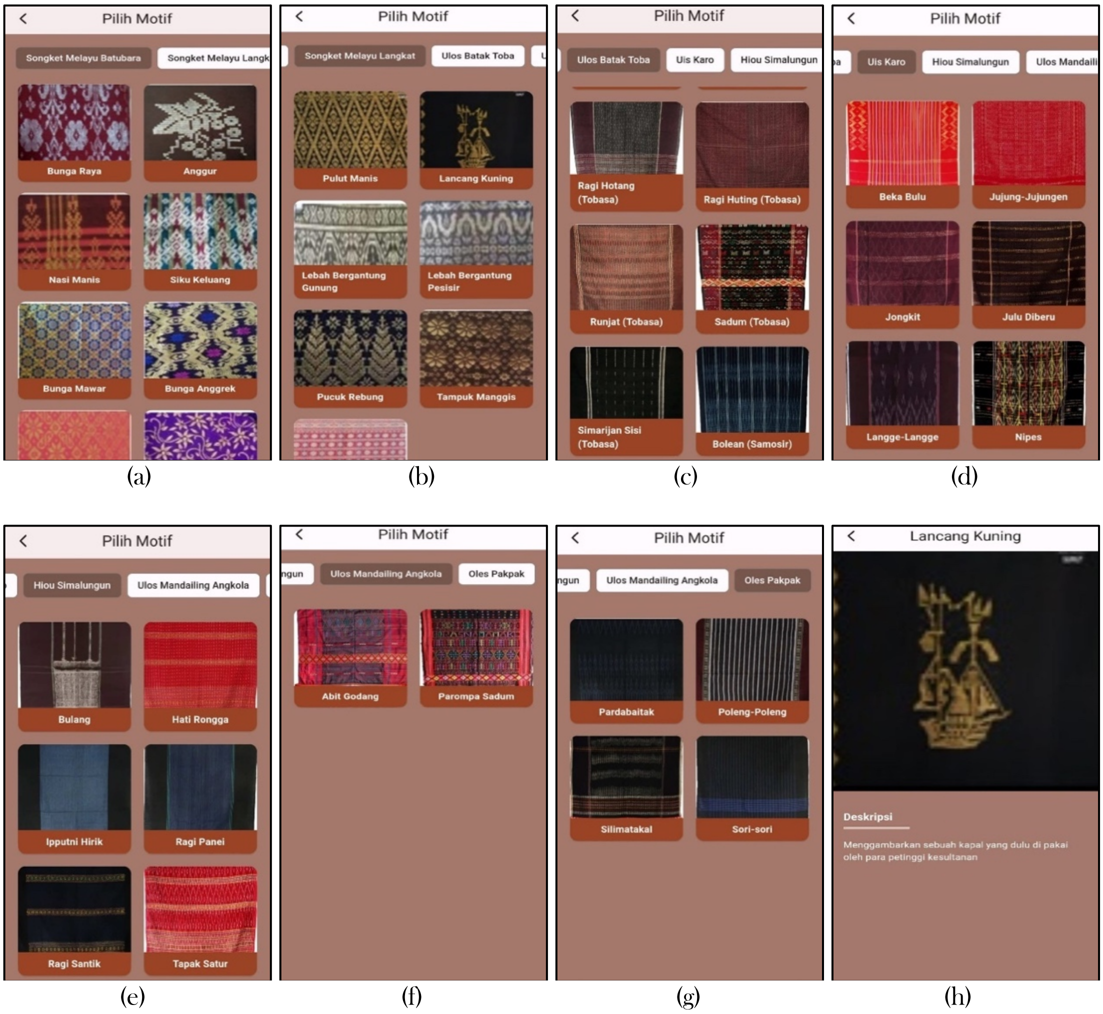


Figure 8. Traditional clothes: songket (a) Melayu Batubara, (b) Melayu Langkat, (c) Ulos Batak Toba, (d) Uis Karo, (e) Hiou Simalungun, (f) Ulos Mandailing Angkola, (g) Oles Pakpak, (h) Description of the *Lancang Kuning* Motif

e) Frieze Patterns Menu

After the image or motif has been edited, the next step is to develop the image or motif using frieze patterns. There are 7 frieze patterns that can be used to generate motifs to produce new designs. The display of the frieze pattern menu can be seen in Figure 9.

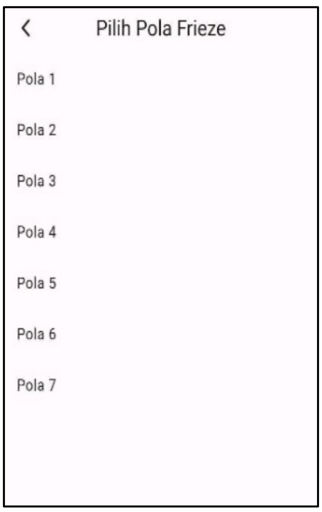


Figure 9. Frieze Patterns Menu

3.4 Testing
3.4.1 Black box Testing

Black box testing focuses on application features such as the design of the interface, the functions offered, and the compatibility of the function flow with user needs [31]. A user test with 30 participants was conducted on core tasks, namely opening the Melukis Batik menu, drawing a base motif, selecting a frieze type, adjusting parameters, previewing the result, and saving to the gallery. Participants reported that the interface was easy to understand, buttons were self explanatory, parameter sliders felt responsive, and real time preview supported quicker iteration. All twelve test cases produced the expected outputs, yielding a success rate of one hundred percent; the detailed scenarios and outcomes are presented in Table 2. Qualitative suggestions included adding an undo history, expanding the color palette, providing multilingual labels, and offering optional presets for common frieze settings. Sessions were moderated and participants were encouraged to think aloud; feedback was documented through observation notes and a short post task questionnaire, and common issues were consolidated into the maintenance backlog.

Table 2. Black box Testing Results

Test Items	Scenario	Expected Results	Status
Homepage	Clicking the "Melukis Batik" button	The screen will show the buttons to paint batik	Successful
	Clicking the "Informasi" button	The screen will show the types of traditional cloth of North Sumatra	Successful
Melukis Batik Menu	Clicking the "Keluar" button	The screen will return to the mobile view	Successful
	Clicking on the "Pola melukis sendiri" button	A working screen will appear to draw	Successful
	Clicking the "Pola yang sudah ada" button	The screen will show the types of traditional cloth of North Sumatra which are differentiated by ethnicity	
	Clicking the "Kembali" button	The screen will return to the homepage	Successful
	Generating motifs that have been drawn with frieze patterns	The results of the motif development will appear on the screen based on the selected frieze pattern	
Drawing on "Pola melukis sendiri"	Choosing a paint pen color	The pen will change according to the selected color	Successful
	Delete a painted image	The drawing will be deleted	Successful
Information Menu	Scrolling traditional cloth types based on ethnicity	The screen will move right or left	Successful
	Clicking on any type of cloth	The screen will display a picture and description of the selected fabric	Successful

3.4.2. Operating Ambatig

After conducting black box testing to verify system functionality, the researcher analyzed the mathematical results of motif generation in the Ambatig application using the seven frieze symmetry types from Type I to Type VII. The chosen motif for evaluation was the *Lancang Kuning*, a traditional Malay pattern characterized by its rhythmic geometric composition and cultural symbolism. In the software, symmetry group theory is encoded by representing the generators of the frieze groups as planar isometries in matrix form using homogeneous coordinates. A user drawn base cell is vectorized into point sets and polylines, then each generator is applied as a transformation step: translation is a shift by a user defined step along the strip direction, vertical and horizontal reflections are mirror mappings across user specified axes, a half turn rotation of one hundred eighty degrees is a rotation about the cell center or an anchor point, and a glide reflection is implemented as a composition of a reflection with a translation along the reflection axis. The algorithm composes these mappings according to the selected frieze type and tiles the transformed cell along the strip before rasterizing the result to the canvas.

The results show that each frieze type produced a distinct structural variation of the *Lancang Kuning* motif while preserving its original proportional relationships. Type I yields uniform linear repetition consistent with pure translation. Type II introduces alternating elements through glide reflection, producing a more dynamic visual flow. Type III forms balanced bilateral structure through vertical reflection. Type IV uses a half turn rotation that emphasizes rhythmic alternation. Type V combines rotation with glide based alternation to increase spatial density. Type VI and Type VII employ reflections in orthogonal directions and their compositions, producing interlocking patterns with higher visual richness while maintaining periodicity. For mathematical validation, Ambatig checks that Euclidean distances between randomly sampled point pairs in the base cell are preserved after each transformation within floating point tolerance, that angles in polylines remain unchanged under translation, reflection, and half turn rotation, and that the determinant of the linear part of each mapping has magnitude one so area scale is preserved. The generated patterns exhibit consistent geometric mapping without distortion or overlap errors, indicating that the implementation faithfully realizes the isometries required by the frieze groups. These results demonstrate the potential of Ambatig as a computational design tool capable of generating creative and mathematically structured batik motifs derived from traditional forms.

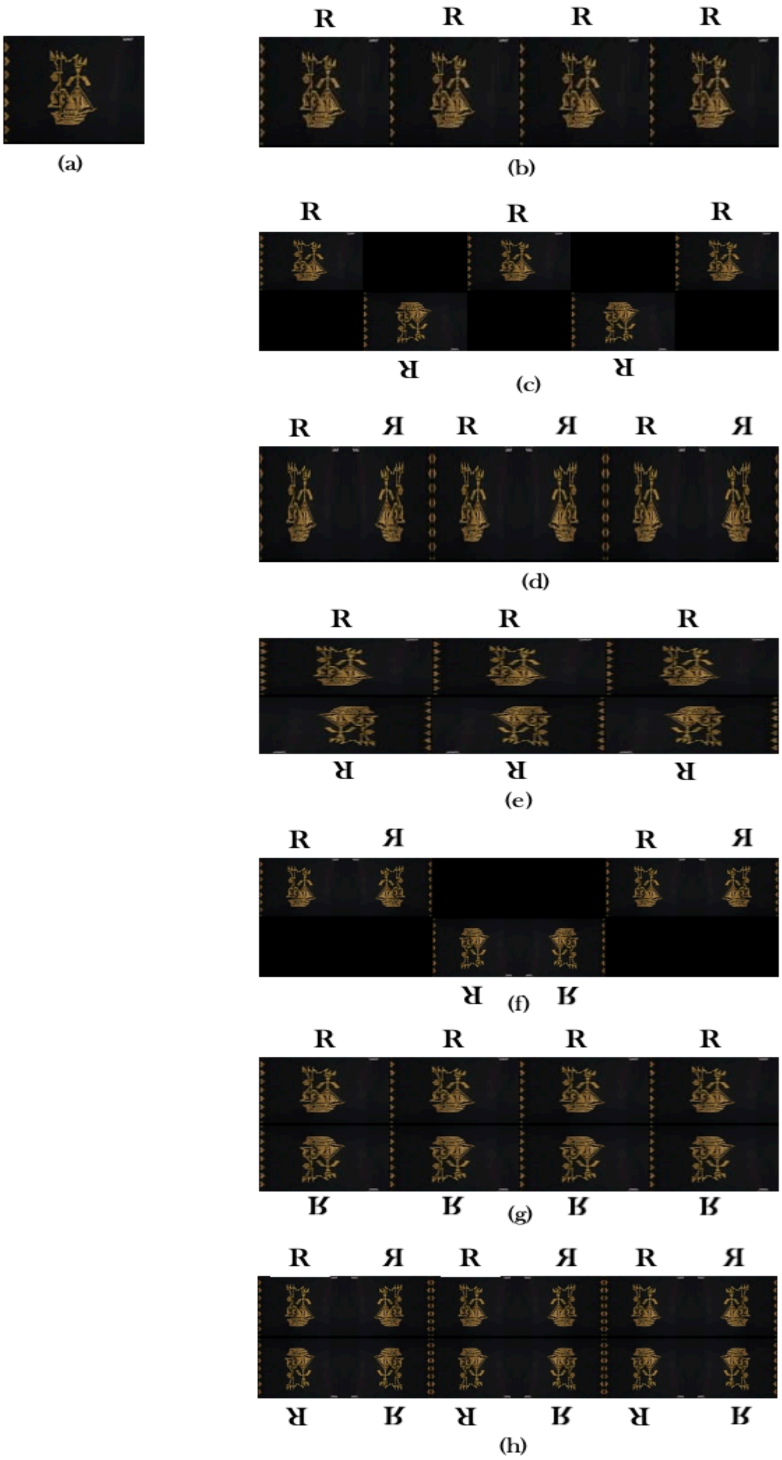


Figure 10. (a) Basic Pattern, Results of Frieze Pattern Generation: (b) Type I, (c) Type II, (d) Type III, (e) Type IV, (f) Type V, (g) Type VI, (h) Type VII

4. CONCLUSION

The Ambatig application was successfully developed using the waterfall model and demonstrated full functionality across all stages of testing. In black box evaluation, all twelve test cases produced the expected outputs, yielding a one hundred percent success rate with no execution errors. A user study involving thirty participants further indicated that the interface was easy to understand, parameter sliders responded smoothly, and real time preview supported faster iteration during motif design. From a mathematical standpoint, computational verification showed that Euclidean distances were preserved within a tolerance of 10^{-8}, interior angles of polyline segments remained invariant under transformation, and the determinant of each linear transformation matrix retained magnitude one. These results confirm that the implemented translation, reflection, rotation, and glide reflection operations function as true isometries and generate repetition structures that satisfy the rules of the seven frieze groups. Practically, the integration of Types I to VII enabled the creation of diverse motif variations while maintaining proportional consistency and periodic alignment. This demonstrates the suitability of Ambatig as a design tool that artisans can use during concept development, layout planning, and motif refinement. Numerical validation also confirmed that repeated applications of the translation generator produced consistent spacing without drift, and that the composition of transformations matched the expected algebraic structure of each frieze group. Future work may extend the mathematical generalization of this system to include two dimensional symmetry classifications such as the seventeen wallpaper groups, dihedral symmetries for rotational motifs, and parameterized affine transformations for controlled deformation of motifs. Further development may also incorporate vector export, multilingual labels, expanded color tools, and presets for common symmetry configurations. Overall, the study confirms that mathematically grounded symmetry operations can be effectively embedded in mobile applications to support both creative exploration and structurally coherent digital batik design.

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