# Chapter 28
# The Interesting Mathematical Approach Toward Analyzing Songket Design

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**Abstract** Songket is an aesthetic fabric which is showed by the complexity of songket patterns which encourage the Malay weavers to be more patient, diligent, and creative in ideas and furthermore become excellent in mathematics. Songket and mathematics cannot be separated as it is needed in all the processes as to produce the beautiful results of songket patterns. This paper is about the analysis of Malaysian songket patterns with the use of 2D plane method which are the wallpaper patterns (badan kain and kepala kain) and frieze patterns on its border patterns (punca kain, kaki kain, and kepala kain). This paper is also based on the classification of Malaysian songket patterns which are from kain sarung and kain lepas/selendang (shawl), based on their geometric symmetries on the plane. It constitutes an extremely valuable tool for this paper because it enables researchers to identify the characterization of songket patterns triggered from wallpaper patterns and frieze patterns. The aim of this paper is to document and catalogue useful guidelines for related professions and database for future references. It will also serve as evidence of the existence of geometric and symmetry patterns on Malaysian songket patterns as a useful contribution to the songket design industry and finally as examples for other Malaysian arts or crafts in having design ideas in an effective way.

**Keywords** Songket • Mathematical pattern • Frieze pattern • Symmetry • Geometry • Pattern transformation

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## 1 Introduction

The fabric which was highly favored in Malaysia for fashioning traditional costumes is songket. Songket is a luxurious product made by weaving silk and gold threads in various indigenous traditional patterns which are very beautiful and extremely varied. In "kain songket," *kain* refers to the cloth or woven material and also the sarong. Most of the Malays used to wear it as clothing during daily or ceremonial occasions such as *kain sarung* with baju *kurung or kebaya*. In the olden days, kain songket was only used by the royalties and people of the palace. "*Tenunan songket benang emas*" and "*kain limar bersongket*" were the most popular handwoven fabrics which are often woven for the imperial family. But nowadays, the *kain songket* is being worn from the ordinary people to the royalties. The history of songket weaving is very difficult to be identified. This is due to the source of reference which is limited and the material itself is very sensitive to be turned into evidence. However today in Malaysia, Terengganu and Kelantan are the two main areas where weavings are still carried out. The techniques and motifs of the Malay weaving could be from the influenced of China, Cambodia, India, and Arab. This condition may be also influenced toward the development of *songket* weaving in the East Coast Malaysia. However, this paper only concentrates on the pattern of the traditional sarong *songket* and to find out the classification of wallpaper pattern and frieze pattern in *songket* textile design.

## 2 Songket

The process of an extra weft weaves where gold threads are inserted into plain weave to create motifs and patterns on the woven fabric is called s *ongket* weaving. Gold-, silver-, and metallic-colored threads are the additional weft threads the Malay weavers use to weave the songket. There are about ten steps in making songket. The process of songket starts with *mencelup warna pada benang* (dyeing), *menerai*, *menganing* (warping), *mengulung* (rolling the warps), *menyampak* (inserting warp through the reed), *mengarat (*making shafts), *meneguh* (tensioning the warps), *gigi belalang* (making *tekat* 3 or 5), *menyongket* (uplifting warps for songket pattern), and finally *menenun* (weaving) [1].

The structure of songket patterns is being created with six basic textile patterns. The six basic textile patterns are full-patterned songket (corak bunga penuh), isolated pattern (songket bunga bertabur), stripe patterns (songket corak jalur berdiri and corak jalur melintang), zigzag patterns (songket corak siku keluang), checkers (songket tapak catur), and the triangle shape of bamboo shoot (songket pucuk rebung) [1]. At the same time, the motif of songket weaving is inspired from plants, cosmos, earth, animals, and nature. The design is mainly concentrated on geometry, whether it is abstract, stylistic, or realistic [2]. The structure of the songket fabrics are mainly in sarong and kain lepas (shawls). Therefore, the structure of sarong songket consists of "kepala kain," "badan kain," and "kaki kain" which include the "mengapit kepala kain" and the "kendik." The "kendik" is the smaller board pattern

that is placed at the "pengapit kepala kain" or at the boarder of kaki kain sarong. Meanwhile, the structure of kain songket lepas consists of punca kain, badan kain, and kaki kain.

## 2.1 Structure of Kain Sarong Songket (Fig. 28.1)

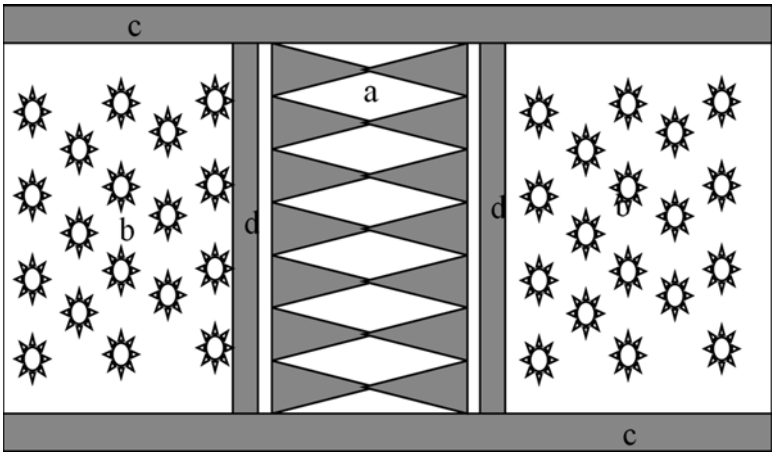



**Fig. 28.1** (**a**) Kepala kain, (**b**) badan kain, (**c**) kaki kain, (**d**) pengapit kepala kain

## 2.2 Structure of Kain Lepas Songket (Shawl) (Fig. 28.2)

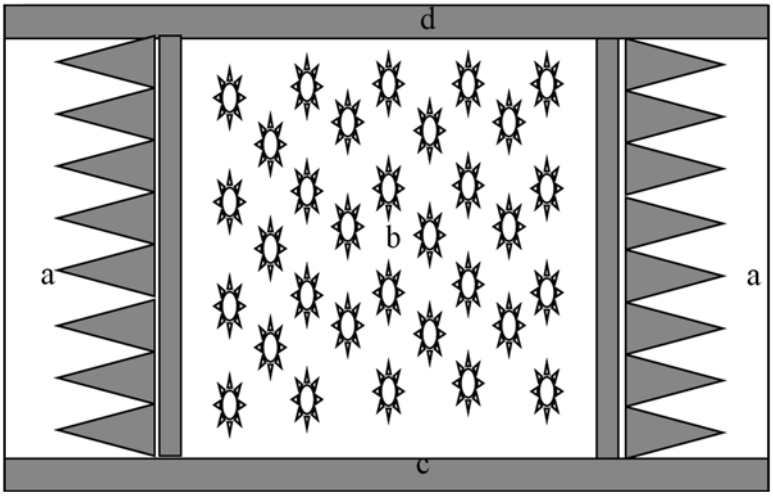



**Fig. 28.2** (**a**) Punca kain, (**b**) badan kain, (**c**) kaki kain, (**d**) pengapit badan kain

## 3 Related Work

Most work related to classifying the pattern in symmetry group mainly aims to study the geometrical concepts of symmetry and pattern. In the work of Djbril M.O. and Thani R.O.H, the authors propose a general computational model for the extraction of the symmetry features of Islamic geometric pattern (IGP) images. In E. Rokiah et al.'s paper, the authors discussed the mathematical thinking of the weavers and the process of *songket* weaving. M. A. Hann writes about the classification and analysis of regular geometric patterns with particular reference to textiles. For this paper, it is based on the traditional Malay *songket* patterns.

## 4 Geometry, Symmetry, and Symmetry Group

The word geometry comes from the Greek words "geo" meaning earth and "metria" meaning mantra or dimension [3]. Geometry is the study of shape, size, and position of both flat-plane figures such as lines, circles, ellipses, triangles, rectangles, and polygons, objects that repeat in an order [4]. The word symmetry also comes from the Greek word *symmetria* which means same measure. Symmetry is when one shape becomes exactly like another if we flip, slide, or turn it. In other words, symmetry is a reflection or mirror. Symmetry is one of the elements in geometry.

The words transformations and symmetry operations are commonly related to the process of moving a motif to another position in the pattern. These processes are involved in motifs and patterns which may be classified with respect to their symmetry characteristics such as translation, reflection, rotation, and glide reflection [5, 6]. Symmetries of a pattern have a group structure. The group structure is named symmetry group of the pattern. Symmetry group consists of three types of periodic patterns which are based on 2D plane (wallpaper patterns and frieze patterns) and 3D plane (crystal patterns) [7].

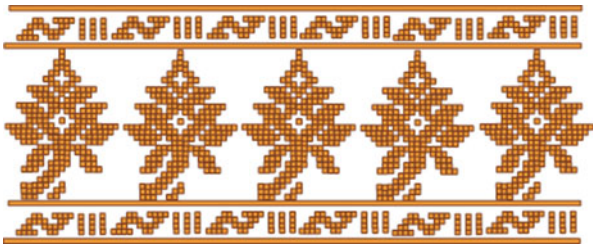
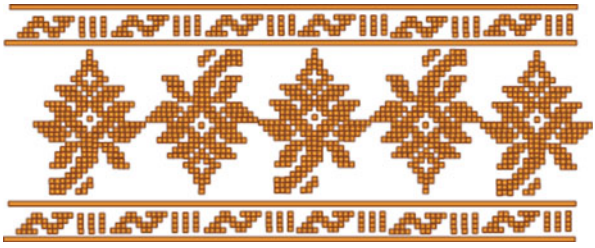
## 5 Wallpaper Patterns

One of the periodic patterns which are based on 2D plane is wallpaper patterns. Wallpaper patterns are involved with the patterns which repeat along two linearly independent directions to tile the plane. Wallpaper patterns consists 17 types of patterns [8]. One of these patterns can be found in all over-patterns of isolated motif or full designed *songket.*

## 6 Frieze Patterns

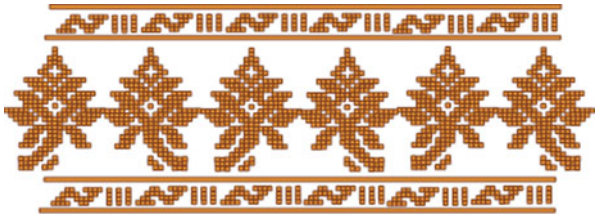
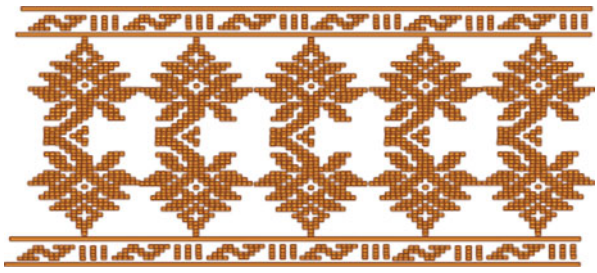
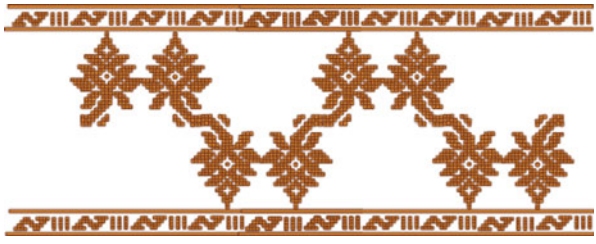
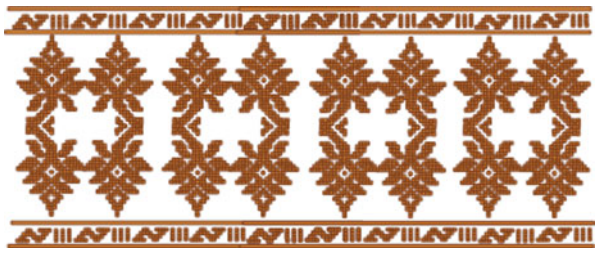
A frieze pattern is an infinite strip with a repeating pattern and it can also be called as border pattern [9]. In architecture, the term "frieze" refers to a decorative carving or pattern that runs horizontally just below a roofline or ceiling. Frieze pattern consists of seven types, and several of these patterns can be found in the border pattern in *songket* [10, 11]. There are seven different frieze groups, as displayed in Table 28.1.

**Table 28.1** Seven types of frieze patterns in *songket* design

| No | Type | Description | Illustration |
|---|---|---|---|
| 1 | 11 | Translation |  |
| 2 | 12 | Translation and 180° rotation |  |
| 3 | 1 g | Translation and horizontal glide reflection |  |

(continued)

**Table 28.1** (continued)

| No | Type | Description | Illustration |
|---|---|---|---|
| 4 | m1 | Translation and vertical line reflection |  |
| 5 | 1 | Translation, horizontal line reflection, and horizontal glide reflection |  |
| 6 | mg | Translation, 180° rotation, vertical line reflection, and horizontal glide reflection |  |
| 7 | mm | Translation, 180° rotation, horizontal line reflection, vertical line reflection and horizontal glide reflection |  |

## 7 Wallpaper Pattern and Frieze Patterns in Songket (Figs. 28.3, 28.4, 28.5, 28.6, and 28.7)

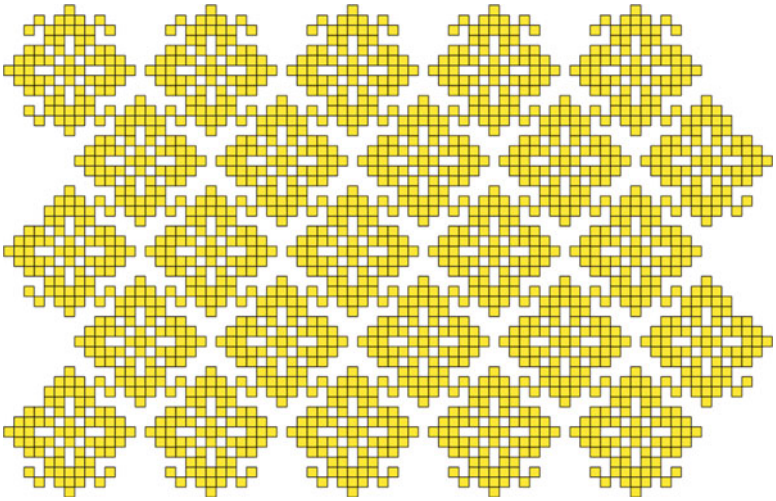


**Fig. 28.3** Wallpaper pattern (*badan kain*) rotations and reflections type cmm

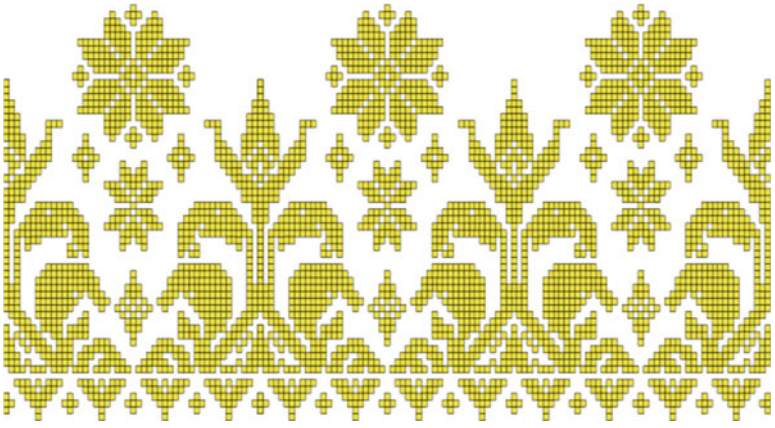


**Fig. 28.4** Frieze patterns (*kepala kain*) translation type 11

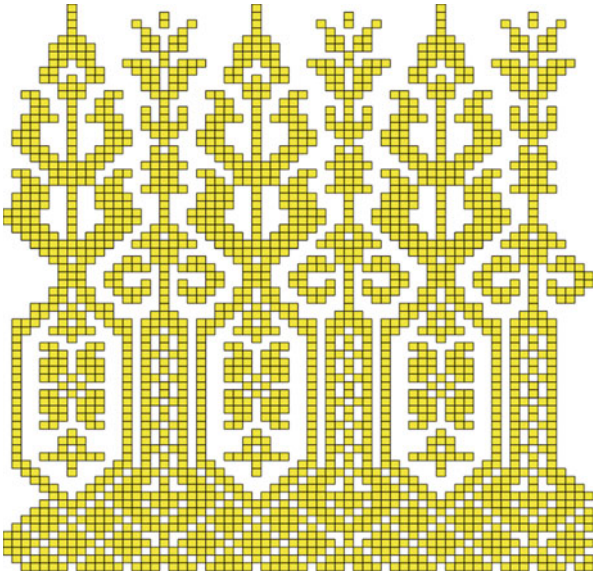


**Fig. 28.5** Frieze patterns (*kaki kain*) translation type 1

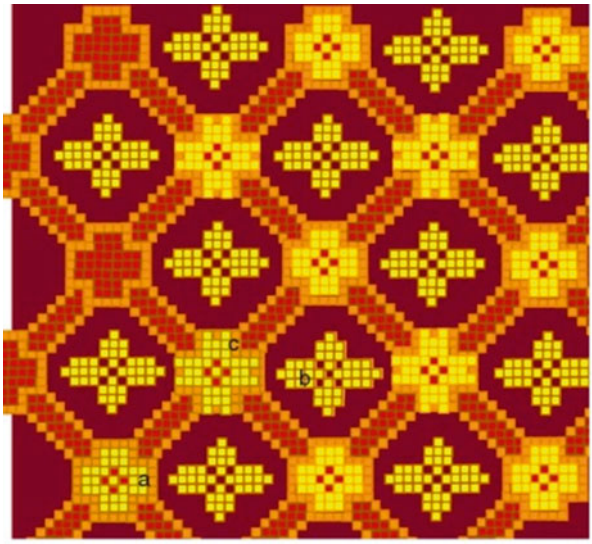



**Fig. 28.6** Wallpaper patterns (*badan kain*) rotations with reflections type p4m – fold rotation centers lie on reflection axes

**Fig. 28.7** Frieze patterns (*pengapit kepala kain*) translation and 180° rotation type 12

## 8 Conclusion

Based on the analysis of s *ongket* patterns in Figs. 28.5 and 28.6, there are rotations and reflection types of pattern on the *badan kain*. The repetition of rotations and reflection *type cmm* and *p4m* are parts of wallpaper patterns. We could see the repetition of translation type 11 in both frieze patterns at *kaki kain* and *kepala* kain. The analyses of *songket* patterns had shown the existence of wallpaper patterns and frieze patterns in the Malay traditional *songket* design. Therefore, the outcome of this paper is to verify that *songket* patterns are mainly repeated in both classifications of frieze and wallpaper patterns. These patterns can be found in "*badan kain*" area, *pengapit badan kain*, *kepala kain*, and at *kaki kain*. It is interesting to identify them at a mathematical classification (in terms of symmetry groups) of repeated patterns into finitely countable classes in which very few researchers had studied on the local textile especially in *songket*. Furthermore the motifs of weaving *songket*

are traditionally composed of geometrical pattern, and the research on geometry of *songket* textiles is involved with the motifs' composition. Therefore, it is essential to fill the gap of the lack of geometry and symmetry research particularly on the elements of *songket* pattern design.

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