Abstract: This paper describes the application of shape grammar in generating new and innovative designs for songket fabric. The traditional Bunga Cabit motif is used as the initial shape where special rules and spatial relation are defined to generate new designs. The rules are based on Euclidean transformations such as translation, rotation, scale, mirror image and combination of these transformations. The specified rules in shape grammar guarantee the generation of new designs that maintained the identity of traditional songket motifs. Samples of new designs using Bunga Cabit and the application of shape grammar are illustrated. New designs using defined rules applied recursively can be used on other traditional motifs in bringing numerous varieties of innovative to the songket industry.

Key-Words: Shape grammar, spatial relation, patterns generation, Euclidean transformation, traditional Malay songket motif, national heritage.

1 Introduction
Songket is a beautiful and high quality hand woven traditional fabric, hailed as ‘Queen of the Malay textiles’[1]. It is viewed as Malaysian heritage fabric. The traditional songket motifs are derived and inspired from cosmos, local and floral environment. Some examples of the traditional motifs are depicted in Fig. 1.

As one prominent Malaysian designer remarked, that traditional songket motifs have been going around for too long that they are no more appealing to the contemporary design driven market [2]. Some efforts are being made in order to rejuvenate the songket industry, including rebranding it as a symbol of luxurious and exquisite fabric, marketing strategies approaches for international markets and introducing new contemporary designs. However, due to stiff competition from mass-produced similar design, that is, brocades which are not only cheaper but have more contemporary designs, songket demand had dwindled substantially and the livelihoods of the cottage industry songket weavers were affected, see [3]. Fig. 2 illustrates some examples of contemporary songket designs.
However, it is the traditional motif that brings out the characteristics of the national heritage fabric from others in the Malay Archipelago. Therefore it is imperative that these motifs are preserved, referred, understood, and innovated from there. As mentioned in Dr Mahathir’s (Former Prime Minister of Malaysia) speech at the opening ceremony of an exhibition “Tradition & Continuity: Woven & Decorated Textiles Of The Malay Peninsula”, organized by Islamic Art Museum Malaysia,

"But we have to remember that in addition to the basic textile functions, textiles support our cultural inheritance since earlier times, particularly at the ceremonial occasions.” [4]

Generating new designs requires creative and innovative minds. This study attempts to explore ways of generating new designs from basic traditional songket motif by using shape grammar. Shape grammar can be used to generate new and original designs by understanding a known existing designs and compositions. Stiny and Gips in [5] indicated that shape grammar allows patterns to be calculated in algebras of shapes. What a shape is depends on the rules used, including when and how these rules are used. Since rules may vary according to one’s creativity, then the probabilities to produce design solutions are numerous.

Shape grammar has been successfully implemented in architectural design of buildings[6,7,8], product designs[8] and painting designs[9]. Several works were done in pattern generation which indicated the validity of using shape grammar. Lee et al. in [10] studied the structures of Bosanghwamun, a traditional Korean pattern. They decomposed the structures of the patterns hierarchically and produced several templates of patterns. Ulu and Sener[11] generated new Islamic geometric patterns from decagons found in an important ornaments of the Islamic art and architecture. Meanwhile, Cui and Tang [12,13] produced new patterns of local cultural features of Yunan and Zhuang embroidery patterns through an auto-generation system embedding shape grammar.

This study focuses on a preliminary attempt to explore and generate new form of innovative songket patterns from a chosen traditional flower motif, Bunga Cabit [12] as depicted in Fig. 3.

Fig. 3. Bunga Cabit Motif

Bunga Cabit is among the simplest motif in traditional Malaysian songket. The motif consists of three squares connected diagonally at the tip, with the middle one slightly bigger than the other two identical sizes.

2 Shape Grammar

Stiny and Gips [5] defined shape grammar(SG) as a 4-tuple: SG = \( \langle V_t, V_m, R, I \rangle \) where

1. \( V_t \) is a finite set of shapes. Their elements are called terminal shape elements.
2. \( V_m \) is a finite set of shapes. Their elements are non terminal or markers. \( V_m \) is such that \( V_t \cap V_m = \emptyset \).
3. \( R \) is a finite set of ordered pairs \( (u,v) \) such that \( u \) is a shape consisting of an element of \( V_t^* \) combined with an element of \( V_m^* \) and \( v \) is a shape consisting of an element combined with an element of \( V_m^* \).
4. \( I \) is a shape consisting of an element of \( V_t^* \) combined with an element of \( V_m^* \).

\[ V_t^* = V_t^+ \cup \{ \emptyset \} \] where \( \emptyset \) is an empty shape and elements of \( V_t^+ \) are formed by a finite arrangement of one or more elements of \( V_t \) in which these elements or their mirror images may be used several number of Euclidean transformations. The sets of \( V_m^* \) and \( V_m^+ \) are defined similarly. Elements of \( R \) are called shape rules where \( u \) and \( v \) is called the left side and the right side of the rule respectively. They are written as \( u \rightarrow v \). \( I \) is called the initial shape and usually has a \( u \) such that there is a \( (u,v) \) which is the element of \( R \).

The step-by-step generation of songket patterns began with the initial shape of Bunga Cabit motif and recursively applied shape rules. The
outcome of applying the shape rule to a given shape is produced on the right side of the rule. A marker was placed on the initial shape to signify the rule application to specific parts of a shape. Four shape rules based on Euclidean transformation were defined to generate basic unit design as shown in Fig. 4. Rule 1 defines translation with the marker to show its orientation. Rule 2 described a vertical reflection. Rule 3 and 4 defined how the motif was rotated at 45° but with a different center of rotation. The markers helped to indicate the direction and rotation center. Rule 5 specify horizontal reflection. Examples of various recursive applications of the shape rules are also shown for each rule.

The generated motifs were then further applied emergent rules to generate more *songket* patterns. In these rules, P represents any generated motif. These rules are also known as emergence rules [14] which are shown in Fig. 5.

Rule 6(R6)

Rule 7(R7)

Rule 8(R8)

Rule 9(R9)

Rule 10(R10)

Rule 11(R11)

Fig. 5. Emergent Shape Rules

Rule 6 reflects an emergent design about a line inclined at 45° at the edge of the emergent design. Rule 7 and 8 reflects a pattern vertically but of opposite directions. Similarly for Rule 9 and 10, the transformations involve a horizontal reflection that is downwards for Rule 9 and upwards direction for Rule 10 respectively. Rule 11 rotates 90° in the clockwise direction with the center of rotation at the edge marked by a marker.

3 Implementation and Discussion

In view with the tedious weaving process, *songket* patterns must not be too complex. At most the rotational shape rule was applied only seven times. Motif-based construction was done in two stage process. The first stage involved generating basic unit pattern design and in the second stage, the emergent designs were used as the basis for further generation. Some basic unit patterns derivations are as in Fig. 6. These derivations are definitely not exhaustive as the probabilities of derivations are just too numerous.
Pattern 1

Pattern 2

Pattern 3

Apply R3-7 times

Pattern 4

Apply R4-4 times

Fig. 6. Basic Unit Designs Derivations

Pattern 1, Pattern 2, Pattern 3, and Pattern 4, were generated by applying Rule 1 twice, Rule 2 thrice, Rule 3 seven times and Rule 4 four times respectively.

In the second stage process, Rule 6 – Rule 11 were applied to the basic unit patterns obtained in Fig.6. The finished patterns are shown in Fig. 7 – Fig. 10.

Fig. 7. Emergent Design Based on Pattern 1

Fig. 7 shows an example of an emergent design based on rules R6→R7→R9→R10.

The emergent design based on the basic Pattern 2 is as illustrated in Fig.8. The rule R11 was used recursively.

Fig. 8. Emergent Design Based on Pattern 2

Fig. 9. Emergent Design Based on Pattern 3

The outcome design in Fig 9 used Pattern 3 to reflect different axes through R8→R9→R7.

Fig.10. Emergent Design Based on Pattern 4

Similarly, emergent design from Pattern 4 was produced through various reflections of R7, R10 and R8 as shown in Fig.10.
In this section we have illustrated new *songket* designs that are obtained by applying the basic rules recursively on the initial *Bunga Cabit* motif. The generated designs still maintain the existing traditional motif that is the central element in the *songket* feature. The applications of Rule 1 – Rule 11 with different recursive procedures can be applied to *Bunga Cabit* motif to produce other distinctive new designs.

### 3 Conclusion

Generating new designs in traditional fabric can be scientifically obtained using shape grammar applications. The advantage of using shape grammar for generating *songket* design is that it provides a powerful tool for capturing the ordering principles that form the basic concepts of style. The rules applied to the selected traditional motif create new designs that retain the traditional element as much as possible. These would form the basis of computerized implementation for pattern creation of *songket* designs.

The generation of other traditional motifs can be applied similarly using shape grammar to produce new designs by keeping the characteristics of traditional motifs. Furthermore, new and more elaborate designs can create more choices that could be more appealing to consumers without sacrificing the *songket* original aesthetic and uniqueness while enhancing the cottage industry.

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