Abstract
Khmer ornament is really important for not only architecture but also Khmer civilization. Because the development of technology dramatically increases, computer becomes the main need for scientists, developers, engineers, designers, and architects. The ornament plays an important role in Khmer architectural design. Since there is no graphical art of the ornament, designers and architects face a difficulty in constructing the ornament again and again. To challenge the problem, we aim to aid them with programmatically generating the art whenever they need. Instead of storing each image of Khmer ornament, we generate the ornament based on a few scalable values or properties such as width and height of the art. In this paper, we experience on a Khmer ornament flower called Phkar Chan for our development.

Keywords: Khmer, Ornament, Architecture, Vector, Digitalization

1. Introduction
Khmer ornament or Kbach (in Khmer) is an important decorative element used extensively in objects and Khmer architecture throughout Cambodia [1]. Artists and architects create Kbach by using ornamental language, a method to create ornaments from basic forms to complex forms. To create complex ornaments, it takes long time despite the help from vector drawing or Computer Aid Design (CAD) software. So far, there is no method nor computer algorithms to generate module based Khmer ornament. Therefore, Artists or architects still need to draw them from scratch by using available tools in the software.

From a related work in [2], the author introduced module-based computer reconstruction methods, which make use of the structuring rule of the lotus motifs. With a similarity of characteristics of lotus motifs and Khmer ornament, this paper introduces similar methods to automatically generate module based Khmer ornaments from a basic form to a complex form.

2. Khmer Ornament Module
At the beginning of our work, we choose Phkar Chan, a flower art of Khmer ornament, to be our experience. The reason we choose it is because it is simple and it is commonly used in Khmer architecture and design. In this section, we discuss on the idea and how we put it into the implementation.

2.1. Idea
We want to generate Phkar Chan module without storing any point or data of it. Since the ornament module has to be drawn in square shape, we think the side of the square is the best parameter for the module. Therefore, we programmatically generate the Phkar Chan module based on the particular value.

2.2. Digitalization
There are two main components of Phkar Chan module: the petal and the heart. The petal component contains two small components can be seen in Fig. 1. The heart has its ring and petal. Furthermore, the module also has some other components such as the sepal. Each component’s location and size is set depending on the square’s side parameter. In this basic of the module, we see that two half-petals is formed into a petal and the petal of the module is mirrored in opposite position to each
2.3. Terminology

Basically, each component is built using point and line. Those lines are drawn using many points. In simple way, straight line needs two points – start and end points. However, to draw a curve line, like Cubic Bezier curve, we need two additional points, which are the control points. The problem is how to find those points? Those points are found using the methods below. However, those points are related to each other based on the square’s side parameter.

2.4. Methods

We use two different methods to find points. First method is called “Grid-based Point Finding”. In this method, we construct each point based on gridding the square’s side. In our experience, Big or simple is needed the grid up to the side divided by 4. Additionally, the grid’s side is equals to the square’s side divided by 128 if the component is complex or small compared to the square’s side.

Another method is called “Geometry-based Point Finding”. The points are found by intersecting lines and geometry’s points. For example, we can find three points from equilateral triangle.

2.5. Experiment

In this experiment, we illustrate the ovary with three petals component using geometry-based point finding method.

Fig. 2 shows about constructing three base points using the methods. To draw the ovary, we use equilateral triangle to divide an inner circle into three portions. Point A can be found using grid-based point finding method. However, point B and C are found by geometry-based point finding method. To draw a Bezier curve between the three points, we need other six control points. To get a prefect ovary, we need sixteen points using our second method as shown in Fig. 3a. Fig. 3b and Fig. 3c show the uses of cubic and quadratic Bezier curves to draw the petals of the ovary. Finally, we get the beautiful ovary as shown in Fig. 3d. This proves that each Khmer ornament uses mathematic and nature to be drawn rather than it is just to be beautiful and meaningless.
2.6. Modules

We currently have two modules. Fig. 4 shows the module A that has only one petal and an ovary with 3 petals and the module B that has two petals, a sepal, and an ovary with 4 petals.

3. Conclusion

Pkharn Chan is programmatically generated based on a side of its frame. We use two different methods to find points to draw each component of the module. We research on the characteristic of the flower and draw it to the original form of

Figure 3. The process of illustrating the **ovary with three petals** component of *Phkar Chan* module

Figure 4. *Phkar Chan* modules (the left side is module A, the right side is module B)
our ancient time. We apply mathematic to the design and make the work of drawing Khmer ornament become faster and better. We believe that this small piece of research will improve Khmer architecture and guide young Khmer generations to love and care of all the golden architecture of Khmer.

4. Further Works

We have many further works to be researched in order to develop our project. You already know that we have done a work of Khmer’s flower art. Our goal is not here. We want to have many themes for each Khmer ornament, not just one. Each ornament has properties to change to size and shape of its components according to the art of Khmer. We then move on to combine the related ornaments together depending on any shape architects need. For example, they want the selected ornaments to fit in their provided canvas. Thus, we need to calculate to size of the canvas and how to organize and position each ornament to the canvas. Our goal is to make an easy way that all related fields of Khmer architecture can obtain the ornament to their works.

References
