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Jenis Karya Ilmiah : Artikel Jurnal
Judul Karya Ilmiah : *Quadratic Bezier Curve as The Base for Pot Modelling*
Penulis : Dzurotul Mutimmah and Novi Prayekti.

Karya ilmiah tersebut dinyatakan benar akan diterbitkan pada :

Jurnal : *Journal of Physics: Conference Series*
Volume : 2279
Bulan/Tahun : Maret/2021

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Quadratic Bezier Curve as the base for pot modelling

To cite this article: Dzurotul Mutimmah and Novi Prayekti 2022 *J. Phys.: Conf. Ser.* **2279** 012008

Quadratic Bezier Curve as the base for pot modelling

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Abstract. Pot is a place or container made of clay, earthenware, cement, or plastic to plant trees or plants. In addition to a place to plant plants, pots also function to decorate the appearance of the house, both on the outside (outdoor) or in the room (indoor). So that the selection of the right pot model can make the yard or corner of the room look more comfortable, beautiful, and attractive. Some pot models that are already on the market have a circular or rectangular base with a monotonous pot shape. Thus, the researcher conducted on the pot modelling with the initial data of regular hexagon polygons as the base of the pot and the Quadratic Bezier curve as the basis for modelling pots with the help of Maple software. This research method uses applied research methods, namely the application of the Quadratic Bezier Curve in making pot models, several pot models were produced, namely a pot with two tiers and three tiers, where each level has several potted models with twisted and symmetrical types. So that the pot models obtained are more attractive and have artistic value.

1. Introduction

Ornamental plants are non-food horticultural plants, which are cultivated to enjoy their aesthetic value or beauty [1]. Ornamental plants are plants whose main function is to decorate. The decoration function is intended as a beauty and attractive or can be enjoyed visually, whether planted in the yard or in the room. So ornamental plants function to create beauty and attractiveness to an object, because they have beautiful shapes and colors [2]. The use of ornamental plants has become a trend for modern people living in urban areas. There are many types of ornamental plants that can be superior products. Superior because of slamming resistance, stable price, and large market opportunities, both local and export, one of them is Aglaonema. In Indonesia this plant is called "*Sri Rejeki*", which means the bearer of luck. There are two types of planting sites for Aglaonema, namely in the ground and in pots [3].

According to KBBI, a pot is a place made of soil, cement, plastic, etc. to plant trees (flowers), usually to decorate a home yard. There are various shapes and sizes of pots that sometimes unique. In addition to the various forms, there are pots that are equipped with a plate-shaped pad. Pot sizes also vary according to their needs, from small to large. The height of the pot also varies, generally according to its shape. But in essence there are two kinds of pot shapes, namely cylinder and cube. Choosing a pot, it is necessary to consider the type of plant, its morphology, the nature of the plant, the planting medium, and where and how the pot will be placed[2]. Selection of the right pot, can make the room and yard look more beautiful and comfortable. So it is necessary to do modeling of ornamental plant pots in order to produce a variety of pot models that are more varied and interesting[4].

Emeralda [5] modeled the shape of the monument using a combination of basic geometric objects and Bezier curves to produce a more varied form of monument models. Astuti [6] also modeled the shelving of goods using Quadratic Bezier curves to produce a more varied, symmetrical, tiered, and balanced shelf model. A Bezier curve is a line formed by two points which can then be curved through the points forming the line. The parametric shape of the n-degree Bezier curve is as follows.

$\boldsymbol{C}(t) = \sum_{i=0}^{n} \mathbf{P}_i B_i^n(t)$ and $0 \le t \le 1$, which:

$$B_i^n(t) = C_i^n (1-t)^{n-i}.\, t^i, t \in [0,1]$$

$$C_i^n = \frac{n!}{i!\,(n-i)!}$$

$\mathbf{P}_i$ = geometric coefficient or fixed point and control curve $\boldsymbol{C}(t)$ [7]. Based on this background, this research will model the ornamental potted plants based on regular hexagons composed of Quadratic Bezier curves with Maple software.

2. Methods

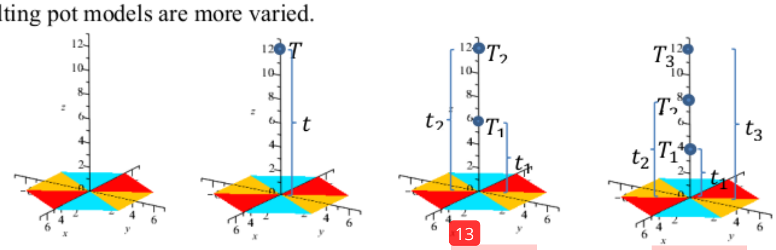
The steps taken to model ornamental potted plants composed of Bezier curves are as follows.

1. Determine the frame of a potted ornamental plant with a height of t and based on a regular hexagon shape, where s is the distance of the center of centroid to the polygon corner, where $12 \le t \le 21\ cm$ and $5 \le s \le 12\ cm$.
2. Divides the height t into two levels and three levels.
3. Fill each level with a Quadratic Bezier curve.
4. Interpolate each Bezier curve in pairs to form a varying pattern.
5. Compiling a computer program using Maple software.

3. Result

This section discusses the solution to the problem of modeling ornamental potted plants composed of quadratic Bezier curves. Given a regular hexagon P_6 centered at $O(0,0,0)$ and its vertices P_1, P_2, P_3, P_4, P_5, and P_6 in the XOY plane, while s is the distance of the center of centroid to the vertex of the polygon, where $5 \le s \le 12\ cm$ (Figure 1.a). Based on these data, the procedure for modeling ornamental potted plants is as follows.

1. Set the point position $T(0,0,t)$ so that the line segment $\overline{OT} = t$ is the height of the ornamental plant pot (Figure 1.b)
2. Divide $\overline{OT}$ into n heterogeneous parts, where $2 \le n \le 3$, so that there are points $O(0,0,t_0)$, $T_1(0,0,t_1)$, $T_2(0,0,t_2)$, and, $T_3(0,0,t_3)$ (Figure 1.c, d). The heterogeneity referred to, t_1 does not have to be the same as t_2. Thus, t_1 can be longer or shorter than t_2, with the purpose that the resulting pot models are more varied.



(a) (b) (c) $n = 2$ (d) $n = 3$

Figure 1. Initial data of regular hexagon polygon

3.1. *Modelization of Ornamental Plant Pots with $n = 2$ (Two Levels)*

1. Constructs a regular hexagon polygon at the heights t_1 and t_2, centered at points $T_1(0,0,t_1)$ and $T_2(0,0,t_2)$ with the polygon's first vertex at points $P_1(s+1,0,t_1)$ and $P_1(s+2,0,t_2)$ as in Figure 2.a.
2. Construct six Quadratic Bezier curves at the first level (Figure 2.b), as follows.

a. First Quadratic Bezier curve C_1 with three control points $P_0(s,0,0)$, $P_1(s,0,t_2/4)$, and $P_2(s+1,0,t_1)$.
b. Second Quadratic Bezier curve C_2 with three control points $P_0(s/2, s/2\sqrt{3}, 0)$, $P_1(s/2, s/2\sqrt{3}, t_2/4)$, and $P_2((s+1)/2, (s+1)/2\sqrt{3}, t_1)$.
c. Third Quadratic Bezier curve C_3 with three control points $P_0(-s/2, s/2\sqrt{3}, 0)$, $P_1(-s/2, s/2\sqrt{3}, t_2/4)$, and $P_2(-(s+1)/2, (s+1)/2\sqrt{3}, t_1)$.
d. Fourth Quadratic Bezier curve C_4 with three control points $P_0(-s,0,0)$, $P_1(-s,0,t_2/4)$, and $P_2(-(s+1),0,t_1)$.
e. Fifth Quadratic Bezier curve C_5 with three control points $P_0(-s/2, -s/2\sqrt{3}, 0)$, $P_1(-s/2, -s/2\sqrt{3}, t_2/4)$, and $P_2(-(s+1)/2, -(s+1)/2\sqrt{3}, t_1)$.
f. Sixth Quadratic Bezier curve C_6 with three control points $P_0(s/2, -s/2\sqrt{3}, 0)$, $P_1(s/2, -s/2\sqrt{3}, t_2/4)$, and $P_2((s+1)/2, -(s+1)/2\sqrt{3}, t_1)$.

3. Interpolating the Quadratic Bezier curve resulting from step (2), which is to interpolate curves C_1 with C_2, C_2 with C_3, C_3 with C_4, C_4 with C_5, C_5 with C_6, and C_6 with C_1 to produce an interpolated surface as shown in Figure 2.c.
4. Construct six Quadratic Bezier curves at the second level (Figure 2.d), which are as follows.

a. First Quadratic Bezier curve C_1 with three control points $P_0(s+1,0,t_1)$, $P_1(s+1,0,(5/4)t_2)$, and $P_2(s+2,0,t_2)$.
b. Second Quadratic Bezier curve C_2 with three control points $P_0((s+1)/2, (s+1)/2\sqrt{3}, t_1)$, $P_1((s+1)/2, (s+1)/2\sqrt{3}, (5/4)t_2)$, and $P_2((s+2)/2, (s+2)/2\sqrt{3}, t_2)$.
c. Third Quadratic Bezier curve C_3 with three control points $P_0(-(s+1)/2, (s+1)/2\sqrt{3}, t_1)$, $P_1(-(s+1)/2, (s+1)/2\sqrt{3}, (5/4)t_2)$, and $P_2(-(s+2)/2, (s+2)/2\sqrt{3}, t_2)$.
d. Fourth Quadratic Bezier curve C_4 with three control points $P_0(-(s+1),0,t_1)$, $P_1(-(s+1),0,(5/4)t_2)$, and $P_2(-(s+2),0,t_2)$.
e. Fifth Quadratic Bezier curve C_5 with three control points $P_0(-(s+1)/2, -(s+1)/2\sqrt{3}, t_1)$, $P_1(-(s+1)/2, -(s+1)/2\sqrt{3}, (5/4)t_2)$, and $P_2(-(s+2)/2, -(s+2)/2\sqrt{3}, t_2)$.
f. Sixth Quadratic Bezier curve C_6 with three control points $P_0(s+1/2, -(s+1)/2\sqrt{3}, t_1)$, $P_1(s+1/2, -(s+1)/2\sqrt{3}, (5/4)t_2)$, and $P_2((s+2)/2, -(s+2)/2\sqrt{3}, t_2)$.

5. Interpolating the Quadratic Bezier curve resulting from step (4), which is to interpolate curves C_1 with C_2, C_2 with C_3, C_3 with C_4, C_4 with C_5, C_5 with C_6, and C_6 with C_1 to produce an interpolated surface as shown in Figure 2.e.

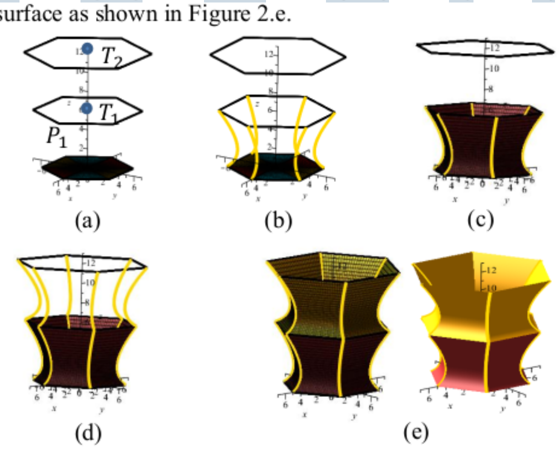


Figure 2. Modelling ornamental plant pots with $n = 2$

Furthermore, several models of two-level ornamental potted plants can be developed by changing the position of point P_1 on each Quadratic Bezier curve at the first and second levels (Figure 3).

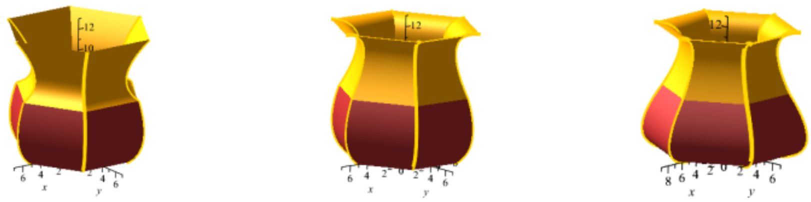


Figure 3. Several two-level ornamental plant pot models resulting from changing the position of point P_1 on each Quadratic Bezier curve

3.2. Modelization of Ornamental Plant Pots with $n = 3$ *(Three Levels)*

1. Constructs a regular hexagon polygon at the heights t_1, t_2, and t_3, centered at points $T_1(0,0,t_1)$, $T_2(0,0,t_2)$, and $T_3(0,0,t_3)$ with the polygon's first vertex at points $P_1(s+1,0,t_1)$, $P_1(s+2,0,t_2)$ and $P_1(s+3,0,t_3)$ as in Figure 4.a.
2. Construct six Quadratic Bezier curves at the first level (Figure 4.b), as follows.
   a. First Quadratic Bezier curve C_1 with three control points $P_0(s,0,0)$, $P_1(s,0,t_3/4)$, and $P_2(s+1,0,t_1)$.
   b. Second Quadratic Bezier curve C_2 with three control points $P_0(s/2, s/2\sqrt{3}, 0)$, $P_1(s/2, s/2\sqrt{3}, t_3/4)$, and $P_2((s+1)/2, (s+1)/2\sqrt{3}, t_1)$.
   c. Third Quadratic Bezier curve C_3 with three control points $P_0(-s/2, s/2\sqrt{3}, 0)$, $P_1(-s/2, s/2\sqrt{3}, t_3/4)$, and $P_2(-(s+1)/2, (s+1)/2\sqrt{3}, t_1)$.
   d. Fourth Quadratic Bezier curve C_4 with three control points $P_0(-s,0,0)$, $P_1(-s,0,t_3/4)$, and $P_2(-(s+1),0,t_1)$.
   e. Fifth Quadratic Bezier curve C_5 with three control points $P_0(-s/2, -s/2\sqrt{3}, 0)$, $P_1(-s/2, -s/2\sqrt{3}, t_3/4)$, and $P_2(-(s+1)/2, -(s+1)/2\sqrt{3}, t_1)$.
   f. Sixth Quadratic Bezier curve C_6 with three control points $P_0(s/2, -s/2\sqrt{3}, 0)$, $P_1(s/2, -s/2\sqrt{3}, t_3/4)$, and $P_2((s+1)/2, -(s+1)/2\sqrt{3}, t_1)$.
3. Construct six Quadratic Bezier curves at the second level (Figure 4.c), as follows.
   a. First Quadratic Bezier curve C_1 with three control points $P_0(s+1,0,t_1)$, $P_1(s+1,0,(5/6)t_3)$, and $P_2(s+2,0,t_2)$.
   b. Second Quadratic Bezier curve C_2 with three control points $P_0((s+1)/2, (s+1)/2\sqrt{3}, t_1)$, $P_1((s+1)/2, (s+1)/2\sqrt{3}, (5/6)t_3)$, and $P_2((s+2)/2, (s+2)/2\sqrt{3}, t_2)$.
   c. Third Quadratic Bezier curve C_3 with three control points $P_0(-(s+1)/2, (s+1)/2\sqrt{3}, t_1)$, $P_1(-(s+1)/2, (s+1)/2\sqrt{3}, (5/6)t_3)$, and $P_2(-(s+2)/2, (s+2)/2\sqrt{3}, t_2)$.
   d. Fourth Quadratic Bezier curve C_4 with three control points $P_0(-(s+1),0,t_1)$, $P_1(-(s+1),0,(5/6)t_3)$, dan $P_2(-(s+2),0,t_2)$.
   e. Fifth Quadratic Bezier curve C_5 with three control points$P_0(-(s+1)/2, -(s+1)/2\sqrt{3}, t_1)$, $P_1(-(s+1)/2, -(s+1)/2\sqrt{3}, (5/6)t_3)$, and $P_2(-(s+2)/2, -(s+2)/2\sqrt{3}, t_2)$.
   f. Sixth Quadratic Bezier curve C_6 with three control points $P_0((s+1)/2, -(s+1)/2\sqrt{3}, t_1)$, $P_1((s+1)/2, -(s+1)/2\sqrt{3}, (5/6)t_3)$, and $P_2((s+2)/2, -(s+2)/2\sqrt{3}, t_2)$.
4. Construct six Quadratic Bezier curves at the third level (Figure 4.d), as follows.

a. First Quadratic Bezier curve C_1 with three control points $P_0(s+2,0,t_2)$, $P_1(s+2,0,(5/4)t_3)$, and $P_2(s+3,0,t_3)$.
b. Second Quadratic Bezier curve C_2 with three control points $P_0((s+2)/2,(s+2)/2\sqrt{3},t_2)$, $P_1((s+2)/2,(s+2)/2\sqrt{3},(5/4)t_3)$, and $P_2((s+3)/2,(s+3)/2\sqrt{3},t_3)$.
c. Third Quadratic Bezier curve C_3 with three control points $P_0(-(s+2)/2,(s+2)/2\sqrt{3},t_2)$, $P_1(-(s+2)/2,(s+2)/2\sqrt{3},(5/4)t_3)$, and $P_2(-(s+3)/2,(s+3)/2\sqrt{3},t_3)$.
d. Fourth Quadratic Bezier curve C_4 with three control points $P_0(-(s+2),0,t_2)$, $P_1(-(s+2),0,(5/4)t_3)$, and $P_2(-(s+3),0,t_3)$.
e. Fifth Quadratic Bezier curve C_5 with three control points$P_0(-(s+2)/2,-(s+2)/2\sqrt{3},t_2)$, $P_1(-(s+2)/2,-(s+2)/2\sqrt{3},(5/4)t_3)$, and $P_2(-(s+3)/2,-(s+3)/2\sqrt{3},t_3)$.
f. Sixth Quadratic Bezier curve C_6 with three control points $P_0((s+2)/2,-(s+2)/2\sqrt{3},t_2)$, $P_1((s+2)/2,-(s+2)/2\sqrt{3},(5/4)t_3)$, and $P_2((s+3)/2,-(s+3)/2\sqrt{3},t_3)$.

5. Interpolating Quadratic Bezier curves results from steps (2), (3), and (4), which is to interpolate curves C_1 with C_2, C_2 with C_3, C_3 with C_4, C_4 with C_5, C_5 with C_6, and C_6 with C_1 respectively on the first level, the second level, and the third level, so as to produce an interpolated surface as shown in Figure 4.e, f, g.

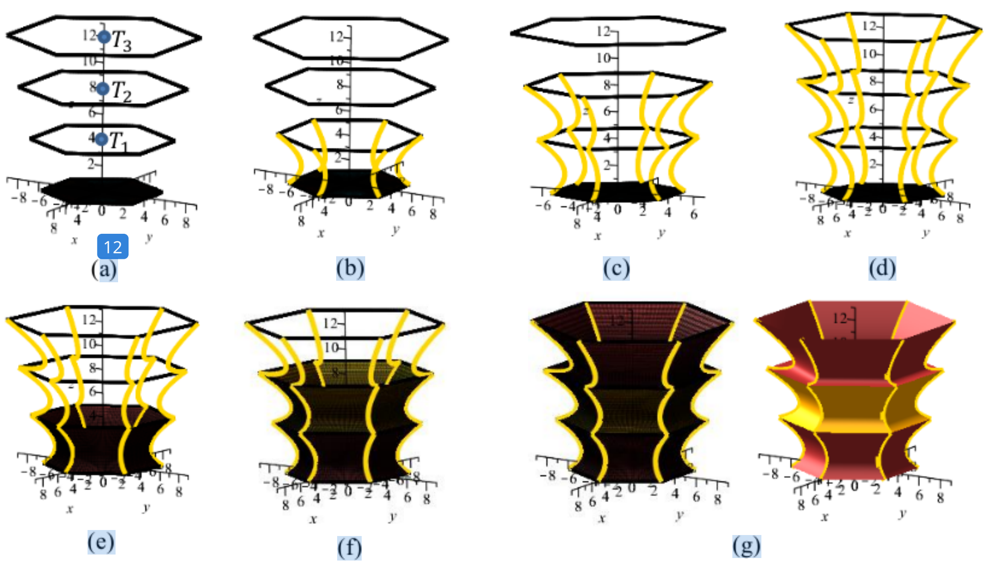


Figure 4. Modelling ornamental plant pots with $n = 3$

Furthermore, several models of three-level ornamental potted plants can be developed by changing the position of point P_1 on each of the Quadratic Bezier curves at the first, second, and third levels (Figure 5).

Journal of Physics: Conference Series **2279** (2022) 012008 doi:10.1088/1742-6596/2279/1/012008

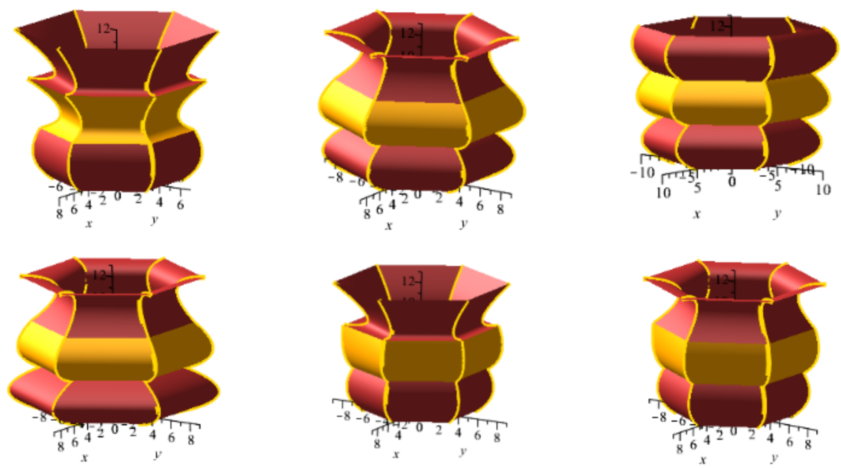


Figure 5. Several three-level ornamental plant pot models resulting from changing the position of point P_1 on each Quadratic Bezier curve

4. Conclusion

The conclusions obtained from this research, namely the procedure for modeling ornamental potted plants as follows.

1. Set a regular hexagon polygon as the base for ornamental plant pots with a potted frame with a height of t.
2. Divide the height t into two levels and three levels.
3. Fill each height with a Quadratic Bezier curve.
4. Visualization of potted ornamental plants using Maple software.

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