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# Allamanda Modeling in Batik Pattern Generation by Using Modified Social Forces Model

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**Abstract:** Allamanda is one of popular decorative plants in Indonesia. This flowering plant can be founded in many house yards easily. Unfortunately, even Allamanda tree is popular, the implementation of this plant morphology into batik pattern is very rare. In this study, we develop Allamanda plant modeling, so that, it can be implemented into batik pattern. Rather than using well known Lindenmayer system, we uses modified social forces model as a basis. The social forces model is very common in modeling human walking pattern. In the other hand, the implementation of social forces model in developing plant growth model is very rare. So, developing plant growth model by using social forces model is very challenging. In this research, we use four forces: desired movement force, interaction force, repulsive force and attracting force. The parts of Allamanda plant that are modeled include: stem, flower, pedicel and leaf. We also combine the Allamanda Model with the modified traditional Parang pattern. Based on the test, the stem tends to grow as a straight line when the implemented force is the desired movement force only. When other forces are implemented, the stem tends to grow wavier. The increasing of the repulsive force weight makes the wavy intensity increases. In other side, the number of obstacles does not affect the wavy intensity. By implementing interaction force, the stem tends to grow wavier when it is close to other stems. When it is far from other stems, the stem tends to grow as a straight line.

**Key words:** Batik, Allamanda, social forces model, continuous system, straight line, stem, force

## INTRODUCTION

Allamanda is one of popular decorative plants, especially in Indonesia. It can grow easily. It is also very tolerant to high intensity of sun light, so that, it usually becomes outdoor plant. This plant is also well known by its trumpet like flower. Most of Allamanda flowers are yellow.

Even this plant is very popular, unfortunately, the adoption of this plant into decorative art, especially, batik is very rare. This plant is less popular than orchid, rose or jasmine. These three flowers can be founded in batik pattern easily. So, it will be challenging to explore Allamanda Model, so that, it can be implemented into decorative art, especially batik.

Besides developed manually, batik pattern can also be generated computationally. The most common method that is used in generating batik pattern pattern computationally is fractal method (Margried, 2015; Hariadi *et al*., 2013). In this research, Hariadi *et al*. (2013) applied Fourier transformation to show that batik has fractal characteristic. Besides batik, fractal method is commonly used to generate lots of nature objects (Banerjee, 2009; Mandelbrot, 1977). The other methods are by using Lindenmayer system, random walk, pedestrian dynamic (Kusuma, 2016) and crack model (Kusuma, 2017a, b). Lindenmayer system is a very well known method in creating plant growth model or plant like model. This method has been used by many researchers because of its basic function in creating branching and shooting mechanism. Besides its origin model, the Lindenmayer system has many derivatives.

In our previous researches, we have developed batik pattern by using pedestrian dynamic mechanism, especially social forces model (Kusuma, 2016; 2017a, b). Basically, social forces model is used to develop human walking or movement behavior and this method is very popular too (Helbing and Molnar, 1995). Many researchers used this model to develop human walking behavior in many specified situations. Mehran *et al*. (2009) used social forces model in detecting abnormal behavior in the crowd. Gao *et al*. (2013) modified social force model and used this model to simulate evacuation scenario. We have used this model in batik pattern generation because human movement pattern can be transformed into artistic pattern. In the previous researches, we used the social forces model in discrete based batik pattern by combining the social forces model with cellular automata where agent's movement choice is limited in four possible directions (Kusuma, 2016; 2017a, b).

In this research, we try to use social forces model as basis model in generating batik pattern computationally in continuous approach. Different from the previous discrete research, the possible direction is not limited into four or eight directions but is depended on the direction angle.

One of the objects that can be modeled in continuous approach is plant growth. So, in this research, we use plant object, especially, Allamanda in batik pattern generation model that is used social forces model as its basis. Allamanda is chosen because of its specific characteristic. Allamanda has thin but long stem, so that, this stem can grow and maneuver more easily rather other rigid plants such as pine, oak or etc. This plant is flexible in following the sun light and very tolerant with the obstacles around it. So, the research question is how to develop Allamanda Model by using social forces model and implement this model into batik pattern generation application.

The purpose of this research is to develop the Allamanda Model by using and modifying social forces model and then implement this model into batik pattern generation application. Different from our previous researches, this model is developed deterministically rather than stochastically.

## MATERIALS AND METHODS

**Allamanda morphology:** Allamanda, especially, *Allamanda cathartica* is a flowering plant that its native is from Northern South America (Mahr, 2010). This plant is en evergreen plant which its leaf color is green for a whole year. It is called as golden trumpet because of its flower morphology which is yellow and trumpet like shape.

This plant is a climbing plant which its vine characteristic is climbing and spreading (Gilman, 1999). This plant can grow up to 15 feet tall or become a shrub that is compatible with its environment (Mahr, 2010). To be growing as a vine, different to the other plants that have tendril, Allamanda needs support structures (Mahr, 2010), such as fence, wall or stone. Allamanda can grow very large, so that, it needs quiet large space.

The Allamanda flower appearance is as follows. The flower or the flower bud grows at the tip of the new shoots (Mahr, 2010). It can contain several flowers or buds at the single flower cluster. The flower contains five large overlapping petals that flare widely (Mahr, 2010). The Allamanda tree and flower is shown in Fig. 1. Fig 1a is the Allamanda tree while in Fig. 1b is the Allamanda flower.

(a)

(b)

Fig. 1: *Allamanda Cathartica*

**Proposed model:** In this research, we propose the Allamanda Model. This model is developed based on social forces model. In this research, we use four forces that are in the social forces model: desired movement force, interaction force and repulsive force and attracting force.

In its basic model, social forces model consists of four forces: desired movement force, interaction force, repulsive force and attraction force. Desired movement force is the force that makes a person goes to the target ($f_d$). Interaction force is the force that occurs because of interaction between person and other persons ($f_{int}$). Repulsive force is the force that occurs because there is wall near the person ($f_{rep}$). Attraction force is the force that occurs because there is object near the person that attracts the person ($f_{atr}$). The illustration of social forces model is shown in Fig. 2. The basic formula of this model is shown in Eq. 1:

$$f_{tot} = f_d + f_{int} + f_{rep} + f_{atr} \quad (1)$$

The explanation is as follows. Basically, social forces model is the resultant of some forces. The desired movement force direction is the same with the target position. The interaction force direction is opposite to the other person position. The repulsive force direction is opposite to the closest position of the wall. The attraction force direction is same with the attracting object position.

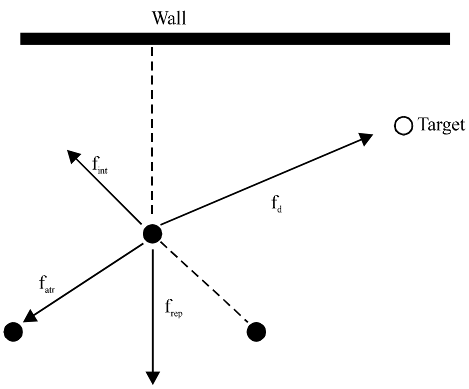


Fig. 2 : Social Forces Model

In this model, each stem has single target. Meanwhile, in the environment, there is condition that there are more than one other persons, walls and attracting objects. So, the interaction force, repulsive force and attraction force is calculated as the summation of each affected things. These three forces are calculated by using Eq. 2-4:

$$f_{int} = \sum_{i=1}^{n_{persons}} f_{int,i} \quad (2)$$

$$f_{rep} = \sum_{i=1}^{n_{wall}} f_{rep,i} \quad (3)$$

$$f_{atr} = \sum_{i=1}^{n_{atr-object}} f_{atr,i} \quad (4)$$

In Eq. 2-4, it is shown that basically, interaction force, repulsive force and attraction force is resultant force too.

Where:

$n_{persons}$ = The number of persons around the person
$n_{wall}$ = The number of walls around the person
$n_{atr\_object}$ = The number of attracting objects around the person

For example, the interaction force for person A is the resultant of person A's interaction force with all of other persons around him. The illustration is shown in Fig. 3.

In this research, the resultant force is modified so that the calculation is simpler. The first modification is by giving weight for each type of force, so that, the priority can be adjusted. For example, if the weight of desired movement force is higher than the weight of the interaction force, it means that the model prioritizes the target rather than the persons around him. The weighted force is shown in Eq. 5. Based on Eq. 5, if there is weight with its value is 0, it means that this related force is ignored from calculation. For example, if $w_d$ is 0, it means that there is no desired movement force that is applied to the stem. So, the stem will grow by the rest three forces:

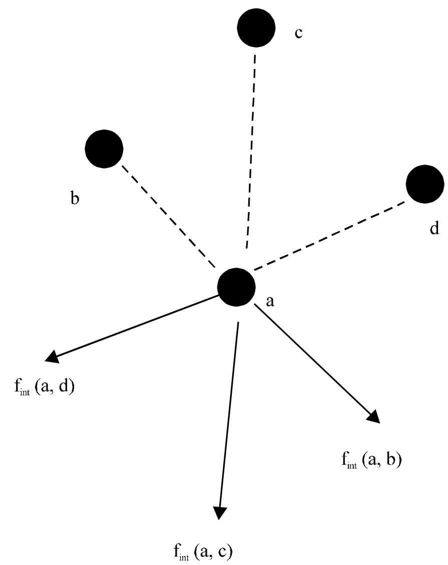


Fig. 3 : Interaction force

$$f_{tot} = w_d.f_d + w_{int}.f_{int} + w_{rep}.f_{rep} + w_{atr}.f_{atr} \quad (5)$$

Each force is divided into two parts, the horizontal force ($f_x$) and the vertical force ($f_y$). The value of these two forces is determined by using Eq. 6 and 7, if the force direction is same with the counterpart position. Meanwhile, the value of these two forces is determined by using Eq. 8 and 9 if the force direction is opposite to the counterpart position:

$$f_x(i, j) = \frac{1}{p_{x,j} - p_{x,i}} \quad (6)$$

$$f_y(i, j) = \frac{1}{p_{y,j} - p_{y,i}} \quad (7)$$

$$f_x(i, j) = \frac{1}{p_{x,i} - p_{x,j}} \quad (8)$$

$$f_y(i, j) = \frac{1}{p_{y,i} - p_{y,j}} \quad (9)$$

In Eq. 6-9, i is the tip of the stem that will grow and j is the counterpart one that may be sunlight source, other stem tip, obstacle or support structure. In this model, each force represents object in the environment. The desired movement force represents the force to follow the sunlight. The interaction force represents the interaction between tips. The repulsive force represents the force to avoid obstacle. The attraction force represents the force to follow the support structure or other attracting objects. After the horizontal and vertical forces are determined, these two forces then are used to determine the expected angle ($\alpha_{exp}$). The expected angle is the direction that should be used by the tip of the stem. The $\alpha_{exp}$ value is determined by using Eq. 10. Because tangential value is repeated every 180° then if the vertical force value is negative then the angle must be added with 180°. The formula is described in Eq. 11:

$$\alpha_{exp} = \tan^{-1}\left(\frac{f_y}{f_x}\right) \quad (10)$$

$$\alpha_{exp} = \begin{cases} \alpha_{exp}+180, f_y < 0 \\ \alpha_{exp}, \text{else} \end{cases} \quad (11)$$

After the expected angle is determined then this value will be compared with the current tip angle ($\alpha_{tip,n}$) whether the current angle is lower or higher than the expected angle. The next tip angle is determined by using Eq. 12-14. In Eq. 12, there are two options: $A_1$ and $A_2$. These options are used to determine the next tip angle. The $A_1$ option is determined by using Eq. 13 while the $A_2$ option is determined by using Eq. 14. In these equations, the $\alpha_{max}$ is the maximum deviation angle:

$$A = \begin{cases} A_1, \alpha_{tip,n} < \alpha_{exp} \\ A_2, \text{else} \end{cases} \quad (12)$$

$$\alpha_{tip,n+1} = \begin{cases} \alpha_{tip,n+1} - \alpha_{max}, \alpha_{tip,n} + 180 < \alpha_{exp} \\ \alpha_{tip,n+1} + \alpha_{max}, \text{else} \end{cases} \quad (13)$$

$$\alpha_{tip,n+1} = \begin{cases} \alpha_{tip,n+1} + \alpha_{max}, \alpha_{tip,n} + 180 < \alpha_{exp} \\ \alpha_{tip,n+1} - \alpha_{max}, \text{else} \end{cases} \quad (14)$$

After the next tip angle is determined then the next tip angle must be normalized. This value must be between 0 degree and 360°. This process is determined by using Eq. 15:

$$\alpha_{tip,n+1} = \begin{cases} \alpha_{tip,n+1} - 360, \alpha_{tip,n+1} > 360 \\ \alpha_{tip,n+1} + 360, \alpha_{tip,n+1} < 360 \\ \alpha_{tip,n+1}, \text{else} \end{cases} \quad (15)$$

This stem growth process will run until the number of segments is reached. After the number of segments is reached, the next research is creating the flower. The first step in flower creation is determining the number of pedicels in a flower cluster ($n_{ped}$). This is a stochastic process and it is determined by using Eq. 16. In Eq. 16, the $n_{minped}$ is the minimum number of pedicels while the $n_{maxped}$ is the maximum number of pedicels:

$$n_{ped} = \text{random}(n_{minped}, n_{maxped}) \quad (16)$$

In this research, not all pedicels become blooming flower. So, blooming ratio ($r_{bloom}$) is used to determine whether the pedicel will become blooming flower or not. This process is determined by using Eq. 17:

$$A = \begin{cases} \text{bloom}, \text{random}(1,100) \le r_{bloom} \\ \text{not bloom}, \text{random}(1,100) > r_{bloom} \end{cases} \quad (17)$$

In this research, the Allamanda leaf is twin leaves. It means that there are two leaves with opposite direction to each other in every stem segment where the leaves grow. Each time the stem grows a random number is generated. Then this random number will be compared with the leaf growth probability ($r_{leaf}$). This process is used to determine whether the leaf will grow from this stem or not. This process is described in Eq. 18:

$$A = \begin{cases} \text{leafgrow}, \text{random}(0,100) \le r_{leaf} \\ \text{leafnotgrow}, \text{else} \end{cases} \quad (18)$$

## RESULTS AND DISCUSSION

**Implementation:** This Allamanda Model then is implemented into batik pattern generation application. This application is a web based application. The application is developed by using PHP language. In this application, the Allamanda pattern is combined by traditional Parang pattern. This Parang pattern is simplified, so that, it can be generated lightly. The result image is shown in Fig. 4.

In this image, some selected colors are used for every object. The color value is formatted in RGB color. These colors are described in Table 1.

Besides the implementation, we also observe the relation between the social forces with the result visually. In the first test, we observe the relation between the repulsive force weight ($w_{rep}$) with the result. The repulsive force weight is set 0, 0.25, 0.5 and 1. The desired movement force weight is set 1. The other weights are set 0. The results are shown in Fig. 5.

Based on the result in Fig. 5, it is shown that when the implemented force is desired movement force only, the

Table 1: Color selection

| Object | R | G | B |
|---|---|---|---|
| Lower background | 246 | 94 | 74 |
| Upper background | 249 | 131 | 115 |
| Stem | 103 | 66 | 18 |
| Leaf | 40 | 150 | 11 |
| Pedicel | 155 | 211 | 22 |
| Sepal | 248 | 206 | 40 |

Fig. 4 : Allamanda batik pattern

pattern tends to be a straight line as it is shown in Fig. 5a. When the repulsive force is implemented besides desired movement force, the pattern tends to wavy as they are shown in Fig. 5b-d. When the repulsive force weight is going higher, the wavy intensity is going higher too.

The second test is to observe the relation between the number of obstacles and the visual stem pattern. The number of obstacles is set 25, 50, 75, 100. The repulsive force weight and desired movement force weight are set 0.5. The other weights are set 0. The results are shown in Fig. 6.

As it is shown in Fig. 6, even the repulsive force makes the pattern is wavier, the number of obstacles does not affect the wavy intensity of the pattern. Comparing the patterns in Fig. 6-d, the wavy intensity among these images is looked similar.

The third test is observing the relation between the interaction force and the result pattern. In this test, the desired movement force weight is set 0.5. The interaction force weight is set 0, 0.3, 0.7 and 1 (Fig. 7). Figure 7d represents the increasing of the interaction force weight consecutively.

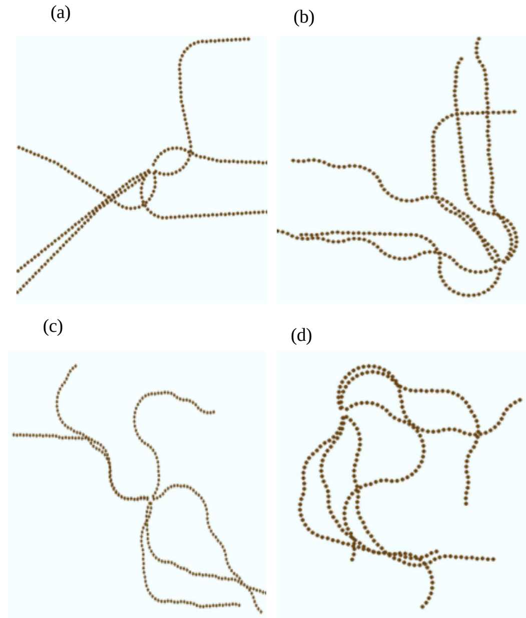


Fig. 5a-d): Pattern with different repulsive force weight

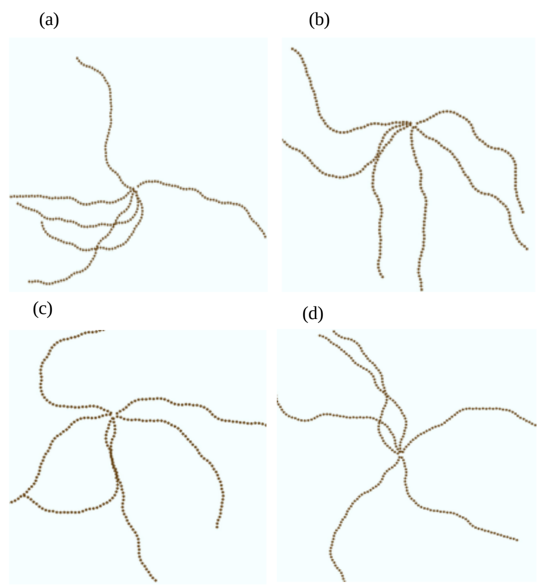


Fig. 6a-d): Pattern with different number of obstacles

As it is shown in Fig. 7, the interaction force makes the pattern wavier. In Fig. 7a where the interaction force weight is 0, the pattern tends to be a straight line. In Fig. 7b-d, it is looked that when the interaction force is implemented, the wavy intensity is higher when a stem is close to other stems. When a stem is far from other stems, the stem grows straighter.

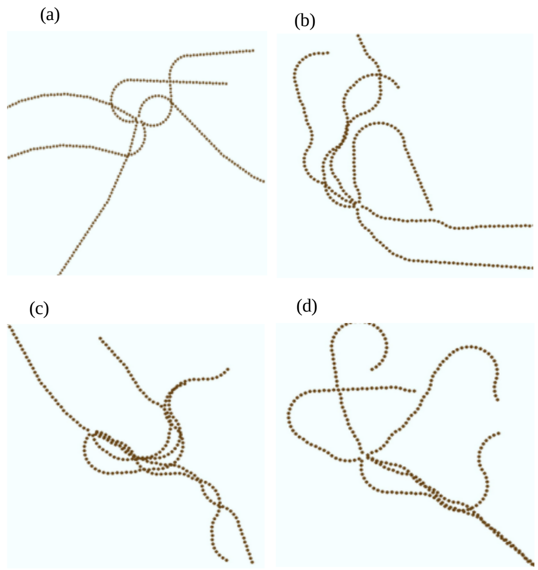


Fig. 7a-d) : Pattern with various interaction force weight

## CONCLUSION

Based on the explanation above, it is shown that the Allamanda model has been successfully developed. This model has also been implemented into batik pattern generation. This Allamanda Model is developed by using social forces model as its basis. In this Model, we implement the four forces: desired movement force, repulsive force, interaction force and attracting force. The sun light represents the target in desired movement force. The obstacle is used in repulsive force. The end of other tips is used in interaction force. The attracting objects are used in attraction force.

## IMPLEMENTATIONS

Based on the test results, there are some research findings. When the desired movement force is the only force that is implemented in the model, the pattern tends to be a straight line. When other forces are implemented, the pattern tends to be wavier. The increasing of the repulsive force weight makes the pattern wavier. The increasing of the number of obstacles does not affect the wavy intensity. When the interaction force is implemented, the pattern is wavier when the stem is close to other stems. When the stem is far from other stems, the pattern tends to be a straight line.

There are future research potentials that follow this current research. As it is mentioned, the Allamanda growth model is depended on the objects near it. So, developing the Allamanda growth pattern with the influence of the objects near it, such as wall, fence or cage is challenging. The other potentials is developing Allamanda Model when this plant interacts with other plants and all of the plants compete to each other for free growth space, water resource or sun light.

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