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The ecological equation of shared bicycles

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ABSTRACT

In this paper to solve traffic problem, we simulate the relationship between the driving amount of the bicycle and the discontinuation space, a mathematical model is established According to the qualitative analysis of this mathematical model, the limit cycle of these two variables is obtained. It can be estimated that the range of driving amount of the Shared cycle is estimated. De pending on the range of driving usage of this Shared cycle. You can decide how much to share your bike. In this way, urban space can be reasonably used and the purpose of urban traffic congestion can be improved.

1. INTRODUCTION

Currently, urban traffic congestion in the world has become a serious problem. Many experts and scholars have put forward many opinions and Suggestions, which have played a positive role in solving the problem of urban traffic congestion.

Papers [1-2] on the issue of tourism marketing, the route planning, choose the shorter path for transport. So, greatly reduce the uneven distribution of urban transportation resources, improve the material blocking pressure of the city.

Papers [3-11] have put forward many opinions and suggestions. In this paper, according to the real traffic situation, choose the sections index, area index intersection index as an evaluation index system, and use the analytic hierarchy process (AHP) to the evaluate model. Through the spot statistics, and quantitative analysis of traffic flow on intersection, such as delay time, of different types of community and the different regions of the synthetically analysis, finally in objectivity and scientific principle, and the evaluation index system has been obtained for surrounding roads open area.

The no signal intersection modeling has been established. Using the formula method, and combining with the traffic conflict to calculate the total traffic saturation and delays for the critical crossing gap and the accessory from the data , and using comparative the analyze the impact on the surrounding roads of plot open before and after ,the index system have been extra-wished. As an example the traffic conflicts and traffic flow data, and total traffic saturation and delay time, have been greatly improved. For the statistical area near the main road and the Angle of the traffic department of city planning and traffic optimization, advice has been given.

About promoting blocks, residential area and the provisions of the unit compound are discussing gradually. The open problems of surrounding roads in this paper, based on the analytic hierarchy process Analytic Hierarchy Process to establish evaluation index system, and choose no signal intersection, through quantitative comparison, C language programming method has solved these problems. Such as the proper evaluating index system is established the mathematical model of traffic, As an example, analysis the influence on surrounding roads after open block type village. Shows that the surrounding of traffic capacity is greatly increased after opening block type village. The traffic department of city plan and the traffic optimization advice are given.

These are all ways to improve congestion by reducing the amount of space used in traffic. And recently, Shared bicycles have sprung up in China. It has greatly reduced the use of public transport because of its convenient use. It is very helpful to improve the city traffic. However, with the increasing number of sharing bikes, the parking space of Shared bicycles is also expanding. That makes up a lot of urban space. There's another kind of traffic jam. Here are two problems: 1. The relationship between the amount of the Shared bicycle and the actual usage. 2. The relationship between urban availability and the volume of Shared bicycles used. These issues have not yet been discussed. This article firstly discusses the question.

2. MAIN RESULTS

Given the following differential equation

$$\frac{dx}{dx} = y - F(x)\,\frac{dy}{dt} = -x \tag{1}$$

We have the following lemma:

2.1 lemma (G. Sansone [12])

In differential equation (1), if it satisfies the following conditions

(1) $F'(x) = f(x) \in c^0(-\infty, +\infty)$;
$\exists \delta_{-1} < 0 < \delta_1, f(x) < 0,\ as\ \delta_{-1} < x < \delta_1; f(x) > 0\ as\ x > \delta_1\ and\ x < \delta_{-1}$

(2) $\exists \Delta > 0, F(\Delta) = F(-\Delta) = 0,$

(3) $F(+\infty) = +\infty, or\ F(-\infty) = -\infty;$

Then there is a unique limit cycle, and is a stable limit cycle.

Let's say that x is the number of actual use of the Shared bicycle. And y is the number of Share the dropping sharing bicycles. The following relationship between x and y is obtained from the intuitive replacement experience. For example let:

$$F(x) = x(x^2 - k) \tag{2}$$

where k>o, that the Ecological equations of Shared bicycles have been obtained

$$\frac{dx}{dt} = y - x(x^2 - kx)\frac{dy}{dx} = -x \tag{3}$$

where $\frac{dy}{dt}, \frac{dx}{dx}$ are the speed of Share the dropping and usage speed of bicycle respectly and the $F(x) = x(x^2 - k)$ is called Damping work, and k is called parameter of Damping work which plays a crucial role in regulating.

2.2 Theorem

For equation (3), there is a unique limit cycle, and is a stable limit cycle.

Proof: because

$F'(x) = 3x^2 - k = f(x)$.

And $F'(-x) = 3(-x)^2 - k = 3x^2 - k = F'(x)$

there is $\delta_{-1} = -\sqrt{\frac{k}{3}} < 0$, $\delta_1 = \sqrt{\frac{k}{3}} > 0$.

Make $f(x) < 0$ as $\delta_{-1} < x < \delta_1$

and $f(x) > 0$. as $x < \delta_{-1}$ and $x > \delta_1$

and $\Delta = \sqrt{k} > 0$, makes $F(\sqrt{k}) = \sqrt{k}\left[(\sqrt{k})^2 - k\right] = F(-\sqrt{k}) = -\sqrt{k}\left[(-\sqrt{k})^2 - k\right] = 0$

$$F(\pm\infty) = \pm\infty$$

According to the lemma2.1, there is a unique limit cycle, and a stable limit cycle.

From theorem we can see Suitable equation have to share your bike's capacity y and share to use After a long enough time The two variables in a relatively stable state. For is suitable for the trajectory equation, when t tends to infinity and the only starting from the rail line $\varphi(x_0, y_0)$:

$$\lim_{t\to\infty^+} \varphi(x(t), y(t)) = \varphi(x(t_0), y(t_0))$$

Its geometry is as follows:

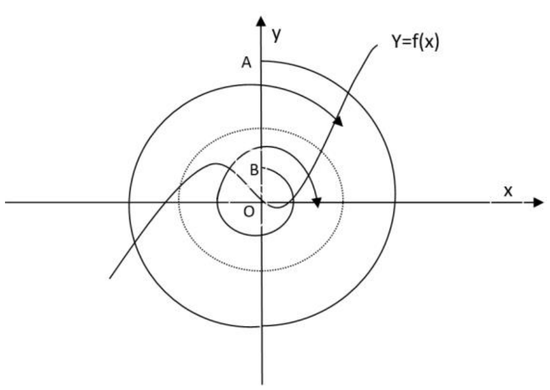

Figure 1. Trajectory map

Pictured above is Shared bicycle trend cart. With the passage of time, the shared bicycle supply will tend to the circle of radius R, and the vector radius of the limit cycle is considered as follows:

$$\|\vec{r}\| = \lim_{x\to\infty}\sqrt{x(t)^2 + y(t)^2} = R < +\infty$$

In equation (2), if let:

2) $F(x) = kx$

Where $k > 0$ and results in

$$\frac{dx}{dt} = y - kx\,\frac{dy}{dx} = -x \tag{4}$$

In equation (3), $\frac{dx}{dt}$ the derivative is obtained:

$$\frac{d\left(\frac{dx}{dt}\right)}{dt} = \frac{d(y - kx)}{dt} = \frac{dy}{dt} - \frac{dkx}{dx}\frac{dx}{dt}$$
$$= x - k\frac{dx}{dt} = -x - k\frac{dx}{dt}$$

Namely

$$\frac{d^2x}{dt^2} - k\frac{dx}{dt} + x = 0 \tag{5}$$

The corresponding characteristics of the equation are:

$r^2 - kr + 1 = 0$: to solve this equation: $r = \frac{k\pm\sqrt{k^2-4}}{2}$. $r_1 = \frac{k+\sqrt{k^2-4}}{2}$, $r_2 = \frac{k-\sqrt{k^2-4}}{2}$. as $k > 2$, $k - \sqrt{k^2 - 4} > k - \sqrt{k^2} = 0$

So $r_1 > 0, r_2 > 0$ and $r_1 \neq r_2$ the two linearly independent solutions of this equation are: $x = C_1 e^{\frac{k+\sqrt{k^2-4}}{2}t} + C_2 e^{\frac{k-\sqrt{k^2-4}}{2}t}$.

In the second equation of equation (3)

from $\frac{dy}{dt} = -x$, we have:

$$y = -\int x dt = -\int \left(C_1 e^{\frac{k+\sqrt{k^2-4}}{2}t} + C_2 e^{\frac{k-\sqrt{k^2-4}}{2}t}\right) dx$$
$$= \frac{C_1}{\frac{k_1+\sqrt{k^2-4}}{2}} e^{\frac{k_1+\sqrt{k^2-4}}{2}t} \frac{C_2}{\frac{k_1-\sqrt{k^2-4}}{2}} e^{\frac{k_1-\sqrt{k^2-4}}{2}t}$$
$$= \bar{C}_1 e^{\frac{k_1+\sqrt{k^2-4}}{2}t} + \bar{C}_2 e^{\frac{k_1-\sqrt{k^2-4}}{2}t}.$$

where

$$\bar{C}_1 = \frac{C_1}{\frac{k_1+\sqrt{k^2-4}}{2}} e^{\frac{k_1+\sqrt{k^2-4}}{2}t}, \bar{C}_2 = \frac{C_2}{\frac{k_1+\sqrt{k^2-4}}{2}} e^{\frac{k_1-\sqrt{k^2-4}}{2}t}.$$

In particular, $k = 2$ the solution of equation (4) is:

$$x = C_1 e^{\frac{k+\sqrt{k^2-4}}{2}t} + C_2 e^{\frac{k-\sqrt{k^2-4}}{2}t} = C_1 e^{\frac{k}{2}t} + C_2 e^{\frac{k}{2}t} = C e^{\frac{k}{2}t} \tag{6}$$

$$y = \bar{C}_1 e^{\frac{k}{2}t} + \bar{C}_2 e^{\frac{k}{2}t} = \bar{C} e^{\frac{k}{2}t} \tag{7}$$

as $k = 2$ and where

$$C = C_1 + C_2, \bar{C} = \bar{C}_1 + \bar{C}_2.$$

Because formula(5),(6),

$$y = \bar{C} e^{\frac{k}{2}t} = \bar{C}\frac{1}{C}x = lx. \quad (8)$$

where $l = \frac{\bar{C}}{C}$

It's a straight line equation and from (6)，(7),following form is correct:

$$y = \lim_{x \to +\infty} lx = \lim_{t \to +\infty} lCe^{\frac{k}{2}t} = \infty. \quad (9)$$

As $k > 2$

The vector model of this solution $\|\vec{r}\|$:

$$\|\vec{r}\| = \lim_{= \to +\infty} \sqrt{x^2 + y^2} = +\infty. \quad (10)$$

Example:

At a certain subway exit in Guangzhou of China, the actual usage of the shared bicycle is $x = 50$,and usage speed of bicycle is $\frac{dx}{dt} = 10$. It is to be considered, and following Damping works, which are to cases, and its parameter of Damping work (control factor) $k = 248$:

$$1).F(x) = x(x^2 - k) = x(x^2 - 248) \quad (11)$$

$$2).\ F(x) = kx = 248x \quad (12)$$

Firstly, case 1), and from the first form in equation (2.3), the share dropping y , which is the reasonable amount of release:

$$y = \frac{dx}{dt} + x(x^2 - k)\Bigg|_{\substack{\frac{dx}{dt} = 10 \\ x = 50 \\ k = 248}} = 110.$$

And the reasonable amount is $y = 110$

Secondly case 2) and from form (6),(7),(8) formula.

$$y = lx \to \infty$$

3. CONCLUSION

This paper discusses the ecological equation of sharing bicycles and draws the following conclusions:

1) If Damping work of Shared bicycle $F(x) = x(x^2 - k) = x(x^2 - 248)$ is adopted and its parameter k is determined according to the actual traffic conditions, and then the reasonable amount of Shared bikes is obtained, according to the actual traffic conditions.

2) If Damping work of Shared bicycle $F(x) = kx$ is adopted and its parameter $k$is determined according to form (8),(9),Over time, the bicycle has lost and emptied, that is the present condition.

The conclusion to the urban traffic management department provides management according to: when to put how many, that makes the reasonable restrictions on businesses, and prevent businesses for profit opportunities, sharing too much on the bike .This number of bicycle sharing can reduce excessive consumption of urban public place, which has positive significance to improve the city traffic.

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