Optimization of Velocity Control of Soccer Robot

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***Abstract*: In the half-dependent robot soccer, quick startup for the robot is needed, the performance of startup can directly influence the accuracy of system strategy. This paper provides a new method of velocity control in case of sliding during the quick startup of carrier. Friction is applied to prevent or reduce the sliding between the wheel and ground. Meanwhile, this paper introduces the optimization of velocity control and corresponding program. Experimental result shows that it is an effective design**.

Index Terms: optimization, velocity control, soccer robot

I. INTRODUCTION

The quick startup is essential in the half-dependent robot soccer match. In the controlling system of the robot, most commanders intend to directly set down the speed of robot. In that way, two wheels of robot may start up at a high speed, which becomes stable after PID control. This could be a good way with convenience and ease, from the control point of view. But, if the inertia of robot is taken into account, the friction between wheels and ground is not large enough to provide required acceleration. Hence, the sliding of wheel to ground happens. Undoubtedly, it would result in inaccurate trace for the robot, or the speed of startup would decrease.

To prevent the sliding during accelerating of robot, friction has to reach certain amount. Two alternatives could be taken to solve this problem: to increase friction or reduce acceleration. Obviously, the best way is an optimization between these two. There are many factors related to friction, among which friction coefficient is dominant. From practical and theoretical survey, several factors such as relative velocity and temperature have great influence on friction coefficient. The relation between sliding velocity and friction coefficient is illustrated in fig 1. To the friction between elasticity and plasticity contact, its coefficient fits to curve 2 and 3 in Fig 1.[1][2].

The following equation explains the change of friction coefficient with respect to temperature.

$$\mu = \mu_A + \mu_D + \mu_A^0 e^{(\alpha+\gamma)A_r} + \mu_D^0 e \frac{\alpha \Delta t}{2\gamma} \quad (1)$$

In which:

μ -total friction coefficient

μ_A^0 -adhesive friction coefficient at initial temperature

μ_D^0 -deforming friction coefficient at initial temperature

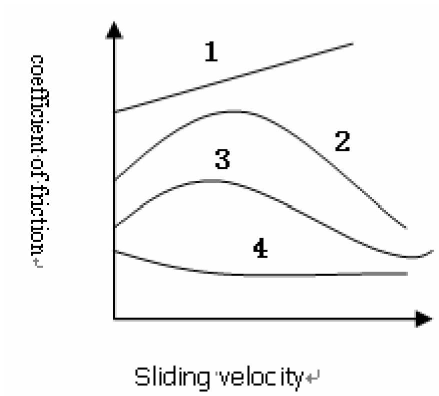

Fig1. Relation between friction coefficient and sling velocity

α and γ -temperature coefficient

Δt -temperature rise

A_r -real contacting area

According to foregoing equation, under most cases friction coefficient may decrease with respect to increase of temperature.[3].Based on theory of change of friction coefficient, strategy of velocity control is designed to achieve a quicker startup speed, and better cooperation with upper computer.

The structure of this paper is as follows: In section two an optimized method of velocity control is provided. A curve is designed, based on which the velocity of carrier is controlled to shorten the startup period. In section three the programming process is introduced. The comparison between traditional control methodology and optimized one is made in section four. The fifth section would be the conclusion.

II. THE DESIGN OF OPTIMIZED ALGORITHM

The speed of robot's wheel is provided by upper computer according to various situations. Lower computer receives command from upper computer, and further controls revolution speed of wheel. Control is not only applied to each wheel, but also to harmonize two wheels, so that better support might be produced to upper computer.

The analysis of optimized algorithm should start from accelerating of carrier. Once static friction is higher than driving power when the robot is speeding up, there will be no sliding between wheels and ground. As known from

Fig.1, if there is sliding happening during accelerating, friction coefficient between ground and wheel would decrease. Temperature rise due to friction will reduce such coefficient more. Consequentially, the counter-acting force between wheel and ground becomes less, hence a lower acceleration. Therefore, a good control to sliding between wheel and ground during acceleration may improve the startup performance of robot.

First of all, we analyzed the variation of velocity of robot at startup period, which is illustrated in the following figure.

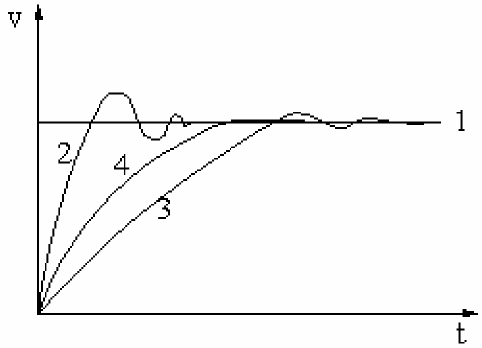

Fig2. Variation of velocity

In Fig 2, curve presents target velocity, curve 2 as speed of system respond, curve 3 as the real velocity and curve 4 as the velocity after optimization.

Some conclusions can be made directly from the observation of figure 2, i.e the rate of velocity changing on start part of curve 3 and 4 is determined by friction coefficient between wheel and ground. Obviously, the changing of friction coefficient is key to optimization.

By controlling robot's velocity, it is able to control its acceleration to prevent or reduce the sliding between wheel and ground floor, and therefore to achieve quick startup. The following is the velocity-time curve we expected. The first part of curve (0%-80%)is straight line with equation of

$$v = \mu g t \tag{2}$$

In which:

μ is coefficient of friction

v is velocity

g is acceleration of gravity

t is time

The rear part of curve is the tangent equation of curve 1 and 2.The coordinate of tangent point is (a, b) and (c, d). The radius of tangent circle can easily be calculated as:

$$r = \frac{a^2 + b^2 + c^2 + d^2 - 2ac - 2bd}{2(d - b)} \tag{3}$$

Then the equation of tangent circle is:

$$(x - c)^2 + [y - (d - r)]^2 = r^2 \tag{4}$$

The equation of expected velocity curve could be derived from the forgoing two equations.

The derived equation is further split by SCM. The expected velocity curve can be achieved by accumulating velocity unit. The startup velocity of robot is not too high. But viewing from the velocity increasing, the robot velocity based on designed curve is higher than the giving one. During the realization of velocity, harmony between two wheels must be taken into consideration when their speed is different. If one speed is not match to another one, robot can not achieve the orbit required by upper computer.

III. PROGRAM DESIGN

In section 2, an ideal velocity curve is designed, while in this section the program for achieving such a curve and the quick startup will be introduced. The flow chart of program is shown in the following figure.

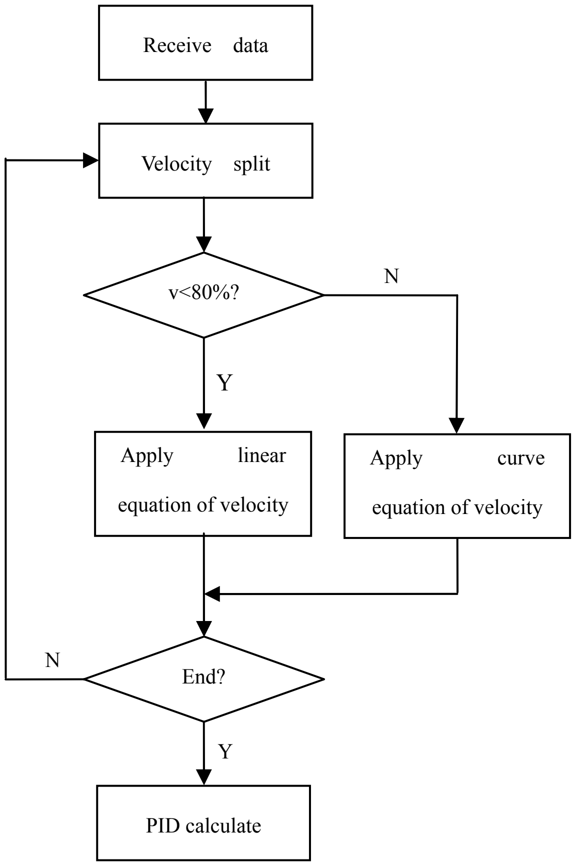

Fig3. Flow chart of program

Firstly, robot receives data from upper computer. Then the speeds of two wheels are identified respectively, and further split at points of 20%, 40%, 60%and 80%. These data are saved into array. Since the curve of speed is a separate function, the correspondent part, at which velocity belongs to, must be clarified. If it is at front part, linear equation is applied to calculate velocity at each point; if it is rear part, tangent lines would be applied in calculation.The result of calculation is saved into an array for using of next function. The next step is to sub-divide the velocity after splitting. To harmonize the velocity of two wheels, the variation of respective velocity must be determined, so that during the sub-dividing the velocity can be split according to their own differences. On basis of experimental method, PMW asks for a rate of 5% for the velocity with bigger difference. In that way, required calculating steps can be derived. Eventually, two wheels will reach the same terminated speed. After that, function

Speed_Control() is applied, which is the main function of this control method. It takes array to calculate the increasing rate of velocity. Meanwhile, velocities after rising should be applied with PID control to improve it respond speed and accuracy. As soon as control result reaches steady state, this function can be ignored. General PID control is enough. So it is quite easy to achieve such a velocity curve, and further to improve its performance.

IV. EXPERIMENTAL COMPARISON

Two robots are taken into experiment. One is applied with traditional control methodology, while another one is applied with our optimized method. Experiment is undertaken on ground for 5 to 5 game. Both of them have same mechanical structure, control circuits and power. Wireless communication is applied for control of start and stop of robot. The results are show in Fig4:

Two robots are placed on the line of penalty area with their positive angle opposite to the goal, same command is sent to them afterwards. In Fig 4, the No.1 robot is under traditional control, while No.2 is under the optimized control. It is obvious the latter one achieves quicker startup than the former one, which means the robot under optimized control can realize the control from upper computer with faster speed.

V. CONCLUSION

1)This paper studies the tendency of variation of friction coefficient. Due to the elastic contact between ground and wheel, temperature and sliding velocity between them have great influence to friction coefficient.

2)Based on the analysis of characteristics of friction coefficient, a curve is designed and correspondent program is commanded.

3)Experiment on the designed curve proves quicker startup under optimized control.

The purpose of speed optimization is to increase the friction between wheel and ground, and further to increase acceleration of robot to reduce required time for startup. It turns out to be an effective way.

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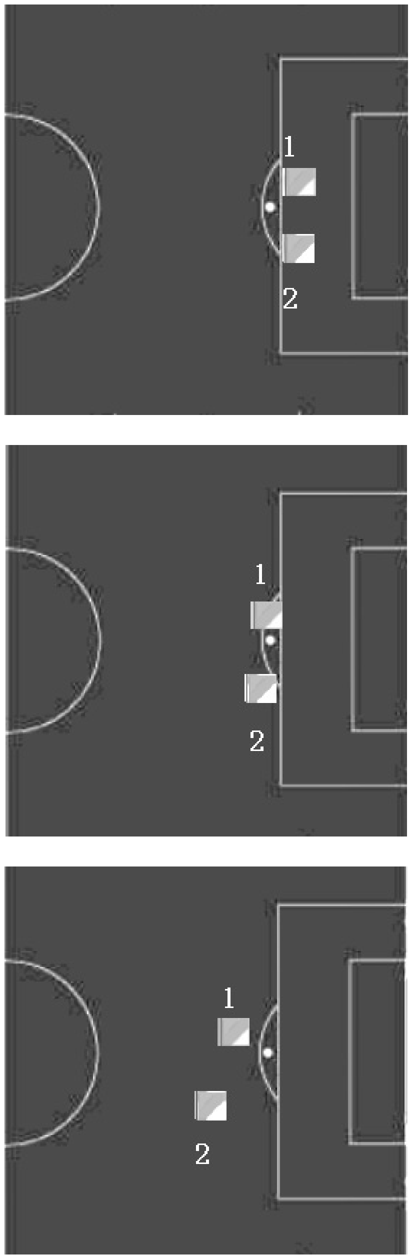

Fig4. Result of experimental comparison