IMPLEMENTATION OF TANGENTIAL KICKING FOR A SOCCER ROBOT

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Resumen

Este artículo describe el desarrollo de un robot jugador de futbol, el cual integra un prototipo de disparo o patada, basado en el principio de la curva tangencial, el cual genera un arco para realizar el disparo. Este efecto se produce debido a la aceleración tangencial que se genera debido el ángulo de la patada o disparo, y lleva el objeto a moverse a través de una zona con diferentes posiciones óptimas para disparar. La patada alcanzada incrementa el grado de libertad del robot y a su vez mejora la eficiencia de tiro, facilitando el control del robot por parte del teleoperador en momentos críticos durante el juego. El control de teleoperación se consigue a través de un dispositivo móvil el cual esta conectado al robot mediante bluetooth. El control que el operario realiza permite realizar movimientos adelante-atrás, girar hacia izquierda y derecha, patear la bola. Estos movimientos se rigen a los principios de odometría que corroboran el rendimiento teórico del diseño. Resumiendo, este diseño proporciona al teleoperador aumentar su porcentaje de aciertos (goles) luego de ejecutar un tiro, esto comprándolo con un modelo convencional.

palabras claves: robot jugador de fútbol, patada tangencial, robot teleoperado, odometría

Abstract

This paper describes the development of a soccer robot, which integrates a prototype of shooting based on the principle of the tangential curve, leading to perform such action into an arch. This effect is caused by the tangential acceleration formed by the angle at the kick, and leads the object to move over an area with different optimal positions for shooting. The kick is aimed at increasing the number of the robot degrees of freedom while improving the efficiency of shooting, thus facilitating control of the device for the tele-operator at crucial moments where the described mechanism is required. Tele-operation control is achieved by Bluetooth technology and allows the device to make different movements, e.g. go forward, turn to the left or right, go back and eventually kicking, all of them referred to odometry principles that corroborate the theoretical performance of the design. To sum up, this robot design provides the teleoperator with a more effective and simpler shooting, compared to a conventional model.

keywords: soccer robot, tangential kick, tele-operated robot, odometry

Introduction

A soccer robot a remotely-operated electronic device designed to perform movements in two dimensions. In addition, the present approach has 4 Degrees Of Freedom (DOF) (1). It is used in robot soccer competitions with two teams of three members each one. The robot can have two or more wheels, which depends on the design of each user / developer. It is managed at distance by different methods, such as radio frequency control and its related technologies, e.g. Bluetooth and WIFI (2).

The design can be limited to different rules that usually have each contest. The propulsion system can be elaborated with micro-motors or others types of engines, such as servomotors and bushels. All of them are driven by a Motor-Driver controller (3), commonly interpreted as H. Bridge based on the geometric plane.

A system of tangential kicking is a method to optimize point shooting between a soccer robot and its rivals (obstacles to beat), which has demonstrated effectiveness when being implemented (4). By applying this concept, the robot is able to solve a state of high speed by a route planning and within a specific area of shot. The objective is chosen according to the principle of least variation.

The trajectory takes place along a circular arc path, i.e. the formation of the tangential shots is performed between the original angle of the robot and the transition from the straight line of curve, after the shot is made. It is worth mentioning that the oscillation induced by the coup at the robot is deleted with original angle adjustment. The tangential cases are shown in Figure 1 (4).

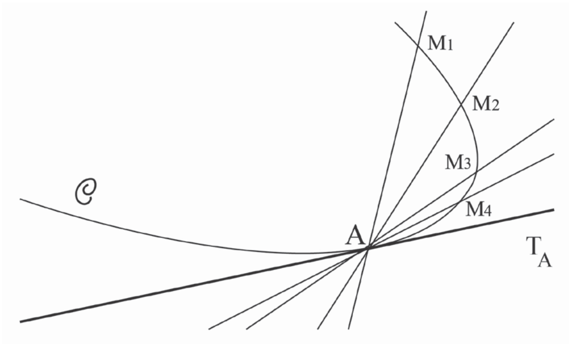

Figure 1. Cases of a tangential curve

Implementing this kicking system provides the tele-operator with a better control of the shot during a game session, thus increasing the robot chances of scoring a "goal" in the opposite arch. A greater number of trajectories at different ways of shooting are generated, by means of the tangential trajectory and the semi-effect of rotation, affecting the impact and displacement.

Methodology

Simple path shooting

A specific contact kicking point of the ball is usually used at the robot mechanism, which is strategically designed so that, at the time of the contact, the ball would meet the principle of the tangential trajectory. The following 5 steps are required to apply the simple path shooting algorithm (4), as it is shown in Figure 2.

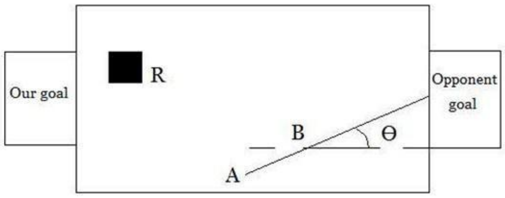

Figure 2. Simple path shooting.

Step 1. The robot shooting points must be calculated. In order to do so, the following equations must be computed:

$$\theta = arctan[(Y_G - Y_B)/(X_G - X_B)]$$

$$X_A = X_B - K \cdot cos\theta$$

$$Y_A = Y_B - K \cdot sin\theta$$

Step 2. The robot R should move to point of shooting A.
Step 3. The robot R adjust the angle of shooting
Step 4. The robot R kicks the ball
Step 5. Return to step 1.

Tangential path shooting

This algorithm is useful in complex game environments, which has several obstacles, so both a path planning and a strategy are required. Figure 3 shows the path generation. The steps below are required to apply the tangential path shooting algorithm (4), as it is shown in Figure 3.

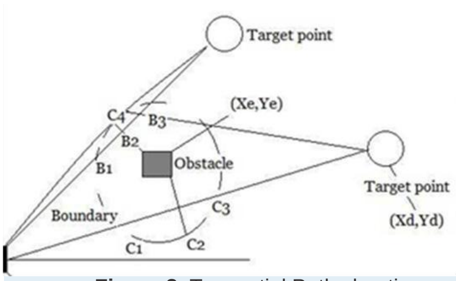

Figure 3. Tangential Path shooting.

Step 1. Set the obstacle as the center of the equation and the parameter W as it radius. Calculate the shortest path and intersect the circumference at the points C1 and C3. Set the shortest vertical path over the center of the obstacles and calculates the intersection of the points C2 and C4 between the vertical path and the circumference.

Step 2. Check the distance between C2 and the boundary.

- If it allows the robot to reach its goal, the next step is to connect the points C1, C2 and C3, generating the path.
- If it does not allow the robot to reach the goal, then connect the point C4, the robot and the target to generate the path.

Soccer Robot design

The soccer robot has 4 actuators (DC motors): 2 of them are intended to move the robot by a mobile base, whereas the other 2 actuators are aimed at setting the kick. The actuators are commanded by a driver that has been installed in the main microcontroller. A Bluetooth module has also been mounted on the main board of the robot, enabling the communication with the mobile device. The robot design is composed of hardware and software modules, which are described in Figure 4.

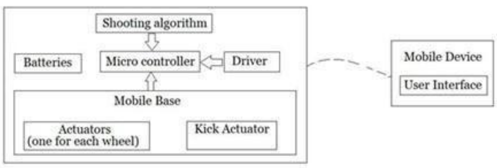

Figure 4. Soccer Robot system

Robot Operation

In order to allow the user to operate the robot, a user application for a mobile device has been elaborated. This application establishes a Bluetooth connection with the mobile device. When the connection between the robot and the mobile is created, the robot can receive data from the mobile application. The data are interpreted by the microcontroller, which also command the actuators of the kicking and the mobile base.

The user can send the followings commands from the mobile application: ahead, go back, turn left, turn right, right kick, left kick and dual kick. The mobile device establishes the communication with the robot by a bluetooth module. When the communications are established, the robot starts to get commands from the mobile application and the micro controller executes them. This is shown in Figure 5.

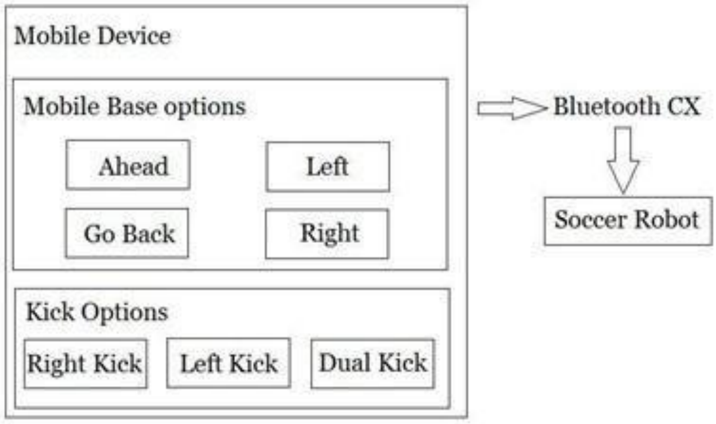

Figure 5: Functionality of the mobile application

Robot Movements

In order to generate the robot movements, a Tri-cycle drive combining steering and driving has been used (5). As the figure 6 shows (5), according to this design, each speed motor defines the trajectory the robot will take.

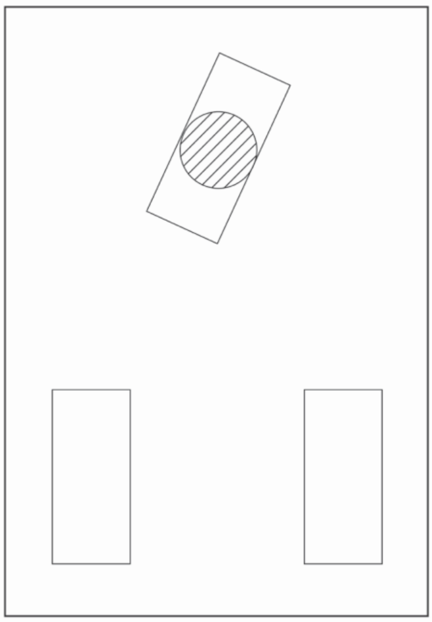

Figure 6. Try-cycle drive.

The Odometry of the robot simplifies the problem in determining the position (6) (7). In addition, the control path is based on speed differences between the wheels. The function of the system can be tested using numerical values of the system. Following a differential drive, as is shown in the figure 7, the robot is able to define it trajectory.

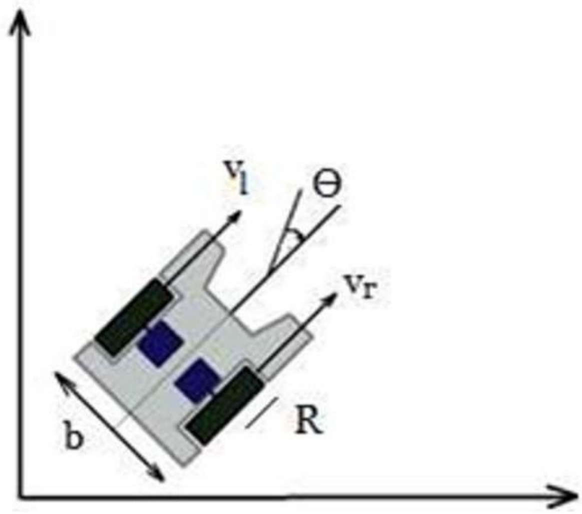

Figure 7. Robot configuration for Mobile differential model

It is required to comply with the 4 steps below (8) for the differential drive (9) to be implemented:

Step 1. Based on the model of the robot, it is necessary to set the relation between the inputs v_Land v_R and the system X, Y and φ, where v_L stands for speed control of the left wheel and v_R stands for speed control of right wheel.

Step 2. Establish the robot movements, considering that the robot can translate itself with linear speed v and rotate with an angular speed w, which are defined by the equations below:t

v=R·[(v_L+v_R)/2]
w=R·[(v_L+v_R)/b]

where b is the separation between both wheels and R stands for the wheel radius.

Step 3. Compute the Integral of v and w, in order to define the robot dynamics, according to the following equation:

x =v·sinθ
y =v·cosθ
φ =w

Step 4. The robot kinematic system is defined next:

$$\begin{pmatrix} \dot{x} \\ \dot{y} \\ \dot{\varphi} \end{pmatrix} = \begin{pmatrix} R\dfrac{cos\theta}{2} & R\dfrac{cos\theta}{2} \\ R\dfrac{sin\theta}{2} & R\dfrac{sin\theta}{2} \\ \dfrac{R}{L} & -\dfrac{R}{L} \end{pmatrix} \begin{pmatrix} v_R \\ v_L \end{pmatrix}$$

Results and Discussion

Figure 8 shows the developed robot. This prototype has been tested in various real competitions. The mobile application also has been tested in different mobile devices, such as cellphones and tablets. Tests on the robot were carried out by

Figure 8. Soccer robot prototype.

means of both the conventional and tangential models, whose aim was to compare the hits between them. According to the results, the latter model makes the robot reach a higher percentage in scored penalty kicks than the former. In fact, Table 1 shows that the tangential model achieves an increase of 30% in effectiveness with respect to the conventional model.

A sample of 10 shots	Tangential kick	Normal kick
Shot speed with motionless ball	1.3 m/s	1 m/s
Reception angle	90°	90°
Angle shot	110°	75°
Scored penalty kicks	7	5
Percentage of score penalty kicks	70°	50°
Scored penalty kicks in a game	7	4
Hits percentage in a game	70%	40%

Table 1: Results of the subjective analysis

The kicking speed increases 0.3m/s when the tangential algorithm is applied, while the reception angle keeps the same value. Another advantage for the tangential kick is the increase of the shooting angle, i.e. without implementing the tangential kick the angle saturates at 75º, whereas it goes up to 110º when the tangential path algorithm is applied.

This increase at the shooting angle allows the robot to get a greater number of fine shots (successes), for both penalty kicks and shots performed in the middle of the game. Therefore, its precision improves 2 points in comparison with a shooting without applying the tangential kick.

Finally, as it can also be seen at Table 1, the tangential model provides the tele-operator with a broader angle shot, thus making the robot handling and operation much easier.

Conclusions

Implementing the tangential kick algorithm on a Soccer Robot leads to an increase of the number of scored goals (fine shots) during the match, hence the success percentage moves from 40% to 70% after implementing the tangential algorithm.

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