# Visually Servoed Radio Controlled Toy Car


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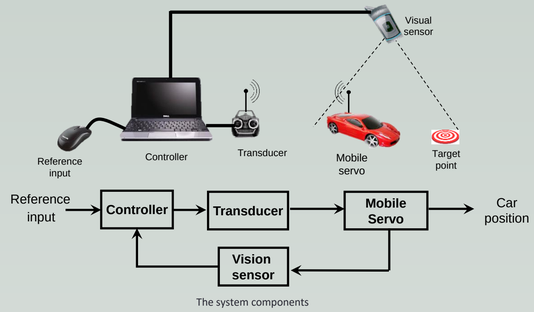
## OVERVIEW

Construct a visual servo system. Command a car to move to a target point based on the mouse input from an external user and an image from the webcam




The system components

The system constraints are:

- Full autonomy (a push button system).
- As inexpensive as possible.
- Maximum utilization of locally available resources .
- Does not harm humans or devices in its surrounding

The system components are:

## SERVO PROCESS

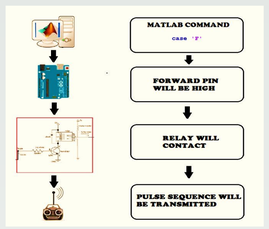
The servo process is an RC car with reduced gear ratio. The car handset can issue seven commands:

| Required Command | Controller Output | |
|---|---|---|
| | Angle | Speed |
| Straight-Forward | 0 | Vm |
| Straight-Backward | 0 | -Vm |
| Right-Forward | θm | Vm |
| Right-Backward | θm | -Vm |
| Left-Forward | -θm | Vm |
| Left-Backward | -θm | -Vm |
| Stop | 0 | 0 |

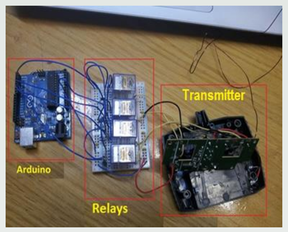
The servo process consists of a toy car and remote control handset. The table shows the possible commands to the toy car.

## THE INTERFACE

Interface: electronically issue the steering commands from Matlab. Made of an Arduino microcontroller and a switching circuit.



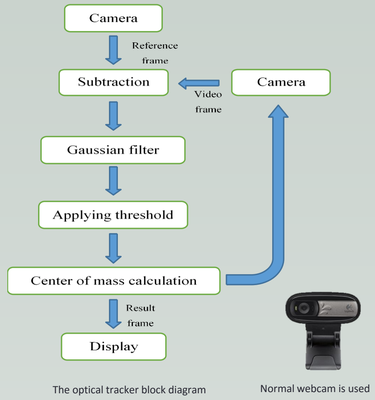

The command flow in the interface




The interface circuit uses transistors and relays as switches.

## THE OPTICAL TRACKER

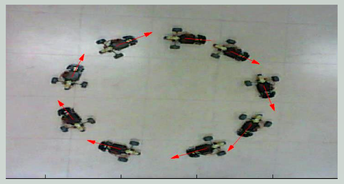
- The optical tracker computes the car location and orientation using background image subtraction.

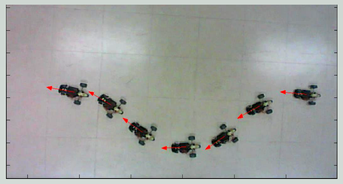



The optical tracker block diagram



Normal webcam is used



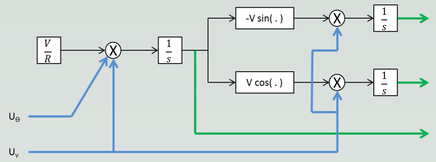


Optical tracker in action

## CAR MODEL

The car's motion can be described by the following equation and block diagram:

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\varphi} \end{bmatrix} = \begin{bmatrix} -u_v v \sin\varphi \\ u_v v \cos\varphi \\ u_v u_\theta \dfrac{v}{R} \end{bmatrix}$$




The system model equation and block diagram

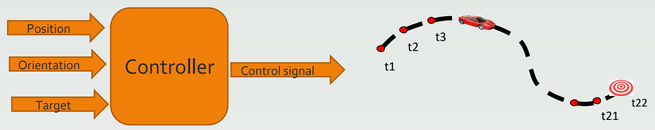
Experiments to identify the car:

The car trajectory when it turns

| Turn | Measurement 1 | Measurement 2 | Average | Speed |
|---|---|---|---|---|
| Forward-Right | 56.88 s | 59.64 s | 58.26 s | 6.18 °/s |
| Forward-Left | 55.49 s | 61.01 s | 58.25 s | 6.18 °/s |
| Back-Right | 43.90 s | 40.56 s | 42.23 s | 8.52 °/s |
| Back-Left | 39.51 s | 38.9 s | 39.21 s | 9.18 °/s |

Measurements of the angular speed of the car turn

## THE CONTROLLER

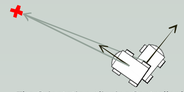



| t1 | t2 | t3 | t3 | t4 | t5 | | t20 | t21 | t22 |
|---|---|---|---|---|---|---|---|---|---|
| RF | LO | LB | OF | OF | RF | | LF | OF | OO |

The controller basic role is to analyze feedback data to give a sequence of commands

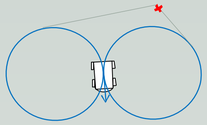
The controller receives the data from the optical tracker and the user defined target and generates a sequence of commands to move the car to the target. Three controllers were developed:

1. Orientation Aligning Controller (OAC): Rotate the car to align its orientation then move to target.



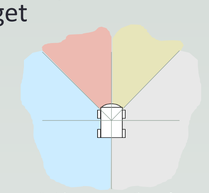
The Orientation Aligning Controller basic principle

2. Tangent Point Controller (TPC): Choose a tangent line on the side circles that contains the target point.

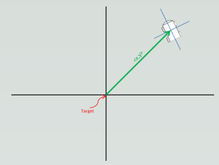


The Tangent Point Controller basic principle

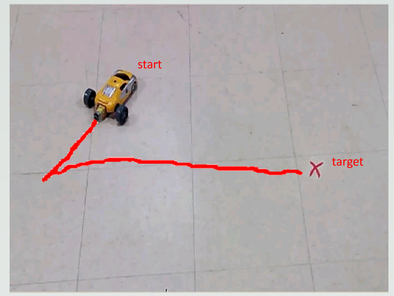
3. Sliding Mode Controller(SMC): Issues commands depending on the target position in the car frame, i.e. the target position looking from the car. The commands in the different switching regions are selected so that the car always moves toward a position in which it faces the target



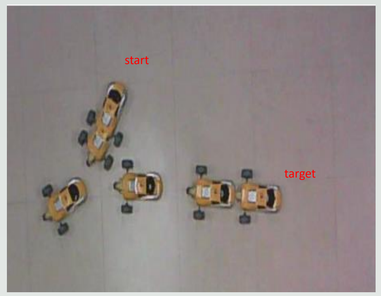
Switching regions in the car frame



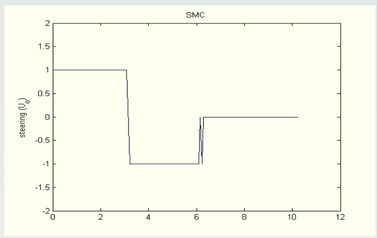

The reference frame and the car frame



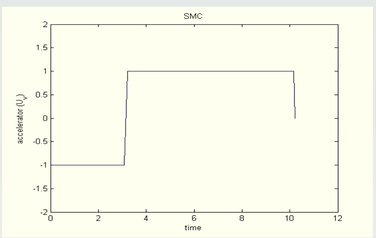

*The experiment setup. Target is the red cross*




The car movement toward the target




The steering commands sent to the car




The accelerator commands sent to the car