

Project Proposal Guide – MATHWORKS TRACK

Disclaimer:

The sample proposal below is to give an idea of how a proposal should be formatted. Our main objective is to illustrate the Design Methodology section - we would like to see a system block diagram of your proposed project. In this document we have also provided information on what Model-Based Design is. Please go through it carefully.

Note that this proposal is not representative of the level of complexity/innovativeness of a winning project. Also, we would expect a more elaborate level of literature review.

You may email Esther Ling, Edu Engineer (esther.ling@techsource-asia.com) if you have any questions. Please mention IMDC 2016 in your subject header.

Project Title: Webcam Tracking of a Green Ball

Abstract

This project proposes a webcam mounted on DC motor to track a green ball in its field of view. An image processing algorithm is to be developed for detecting the green colour. The position will then be determined based on the green colour, and its coordinates will be feedback to the microcontroller (Arduino). The Arduino will turn the DC motor accordingly to position the webcam such that the green ball is maintained at the centre of the webcam's field of view. A PID controller is to be developed to control the DC motor movement accurately.

Project Introduction

Object tracking is vital in applications such machine vision in manufacturing environment for picking up a desired object accurately within its working space [1]. An image processing application coupled with precise control of the robotic vision system is to be developed for this purpose.

This project can be divided into:

- a) A machine vision system that can track a green ball,
- b) A microcontroller that feeds the tracked green ball position and control the position of the vision system,
- c) A prototype system consisting of a custom designed board that realizes (a) and (b).

Model-based design (MBD) will be utilized as design methodology in this project to work out the design efficiently and quickly.

With MBD, we can divide the system into different subsystems (i.e. motor driver subsystem, image processing subsystem, supervisory logic control subsystem) and have a different team member work on an assigned subsystem. Each team member will use the necessary MATLAB toolbox(es) to model and simulate the subsystem until the proper design is achieved, before proceeding into making the hardware, integrate and test run it.

Design Methodology

Figure 2 shows the system design of the entire setup. It consists of a host computer with a Simulink graphical user interface program that configures the Arduino and its peripherals. A webcam is mounted onto a DC motor. The DC motor itself is a hacked RC servo where its internal controller is to be disconnected and function as a DC motor with angle feedback via potentiometer resistance.

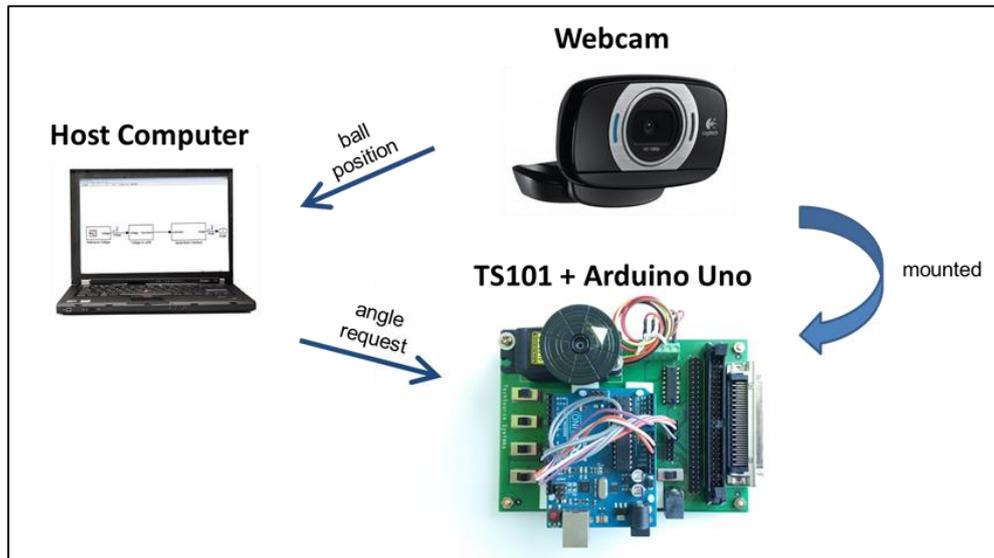


Figure 1: System level block diagram

We propose to use MATLAB to create a mathematical model of a DC motor and to design a controller for the DC motor. We plan to model the plant using Parameter Estimation. Parameter Estimation method is used when parameters are not defined or known, and has been widely used in various studies to determine DC Motor parameters, as in [2] and [3].

In order to drive the motor fast and accurately, our PID controller will need to be tuned appropriately. We plan to use the Control System Toolbox to achieve this. Our control system modelling and prototyping will be divided into four stages. The following briefly details the four stages, which forms the basic workflow of this project.

Stage 1: Data Acquisition

- Obtain the information/data required for parameter estimation process.
- Record the output data based on the certain specific input.

Stage 2: System Identification

- Model the plant/system by performing parameter estimation using MATLAB.
- Verify the plant/system with other sets of data.

Stage 3: Controller Design

- Design a PID controller for the plant/system.

Stage 4: Real Time Testing

- To deploy and observe the controller response in the Arduino Uno on the TS101 board.

On the camera side, an image processing algorithm is to be developed such that the green ball can be tracked accurately and its position fed back to the motor control subsystem. The Image processing subsystem is to be developed with the image processing toolbox and computer vision toolbox. Different object tracking algorithms such as thresholding and Kalman filtering will be modeled and simulated to get the best green ball tracking mechanism.

References

- [1] J.-O. E. Henrik I. Christensen, "Artificial Intelligence: Machine Vision," in *Van Nostrand's Scientific Encyclopedia*, John Wiley & Sons Inc, 2005.
- [2] D. Seaton, "Brushed DC Motor Control: Parameter characterization, open loop and PI controller simulation," 2010. [Online]. Available: <http://www.egr.msu.edu/classes/ece480/capstone/fall10/group04/Seaton,%20Dave%20-%20Application%20Note.pdf>. [Accessed 02 September 2015].
- [3] B. V. S. R. S. C.Ganesh, "DC Position Control System – Determination of Parameters and Significance on System Dynamics," *ACEEE Int. J. on Electrical and Power Engineering*,, vol. 03, no. 01, 2012.

Understanding Simulink and Model-Based Design¹

Simulink is a visual design tool in the overall MATLAB computational environment that facilitates Model-Based Design.

Simulink provides a graphical modeling environment for dynamic system development and design. You can use Simulink to visually develop the following:

- Physical system plants (system ordinary differential equations)
- Controllers/compensators/control algorithms (controller difference equations)
- Filters and sensors

Tightly integrated with its modeling environment, Simulink also provides a convenient simulation environment for analysis, refinement, and validation of the designs.

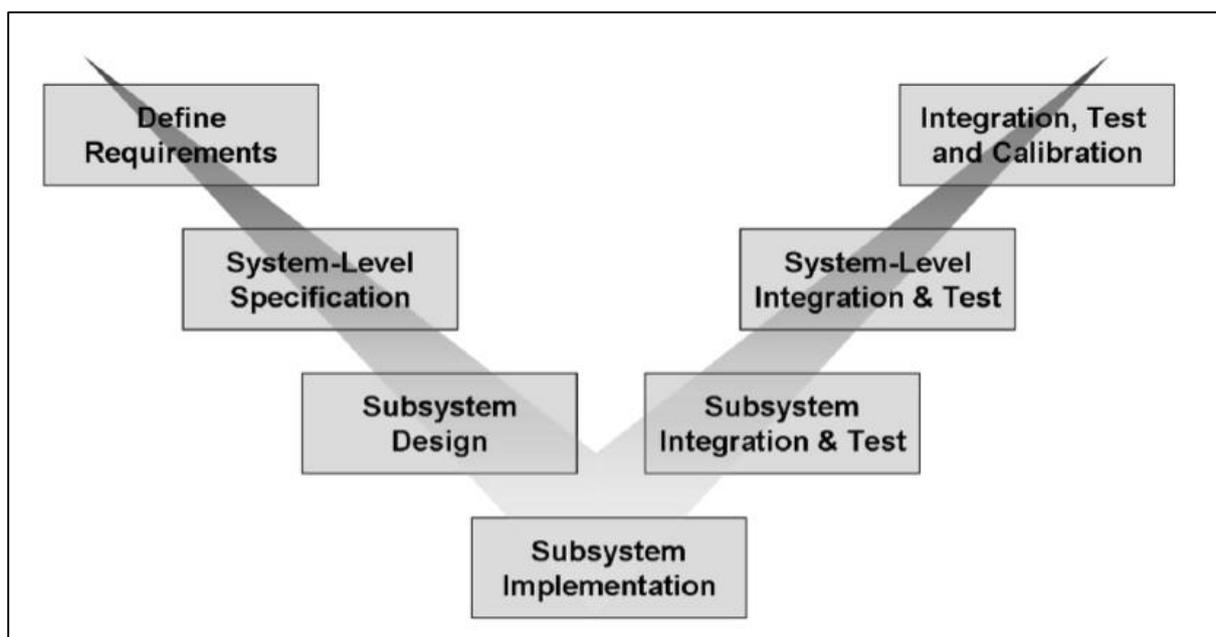


Figure 2: Systems Design Process (V diagram)

The systematic design and realization process in many industries is represented by a V diagram as shown in Figure 1. The two branches of the V correspond to two distinctly different activities:

- The left branch captures the decomposition of the initial system requirements into subsystems and components that are specified and implemented at an increasingly detailed level.
- The right branch represents the realization of these subsystems and components and their integration.

Model-Based Design refers to the process of using models throughout a design process. It starts with the conceptual phase, in which you might try out an idea using a graphical model and simulation. You elaborate the model, adding more detail at each design iteration. Finally, you realize the tested design in hardware.

¹ The information in this section is © 2014 by MathWorks, Inc

Webinar on Model-Based Design:

<http://www.mathworks.com/videos/introduction-to-model-based-design-modeling-and-simulation-with-simulink-99769.html>

Example Arduino Projects using Simulink in Mathworks File Exchange:

<https://www.mathworks.com/matlabcentral/profile/authors/6650597-techsource-technical-team>