University of Illinois at Urbana - Champaign
Department of Electrical and Computer Engineering

PV Autonomous Golf Ball Retriever

Project Proposal

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1. Introduction

Golfers and non-golfers alike regularly visit driving ranges to hone in on new skills, develop existing strokes and techniques, or sometimes just for pure pleasure. Most casual players will hit around 40-60 golf balls in an hour's time while the more professional players usually go beyond this. Our group wishes to address the issue of golf ball retrieval on driving ranges. The current method of retrieval consists of a man operated customized truck that has cylinders in front of the cab to pick up golf balls and place them in bins. Many man hours are wasted daily by retrieving these balls to replenish the driving range. These bulky machines are also costly and the wheels can ruin the driving range. An autonomous robot has been created to address these problems and is currently on the market to buy. Our team will also create an autonomous robot but it will have significant improvements over the current model which includes solar power and computer vision. Our team will use our engineering skills in the areas of robotics, solar power systems, image processing, and motor controls to complete this project. We will design an autonomous photovoltaic golf ball retrieving robot that uses computer vision to find the nearest golf ball in its path as well as automatically detect when our storage unit reaches capacity.

Features:

- Solar powered battery charging
- Fully autonomous collection, no user input needed to monitor robot
- Nonstop golf ball collection using axial mechanical retrieval method (Figure 1)
- Image processing allows for more efficient routes to golf ball retrieval to be implemented
- Fully electric battery powered system (not gasoline)
- Will not overfill and has release mechanism

- Ball counter to initiate halt state

Benefits:

- Time savings from having to pick up each individual ball
- Green solution to golf ball retrieval
- Easy to use since it has autonomous pickup
- Reduces wear on green as opposed to heavy collection vehicles
- More efficient routes to balls are calculated resulting in less energy wasted
- Less initial capital cost than current methods
- Ability to retrieve balls in compact locations due to high maneuverability

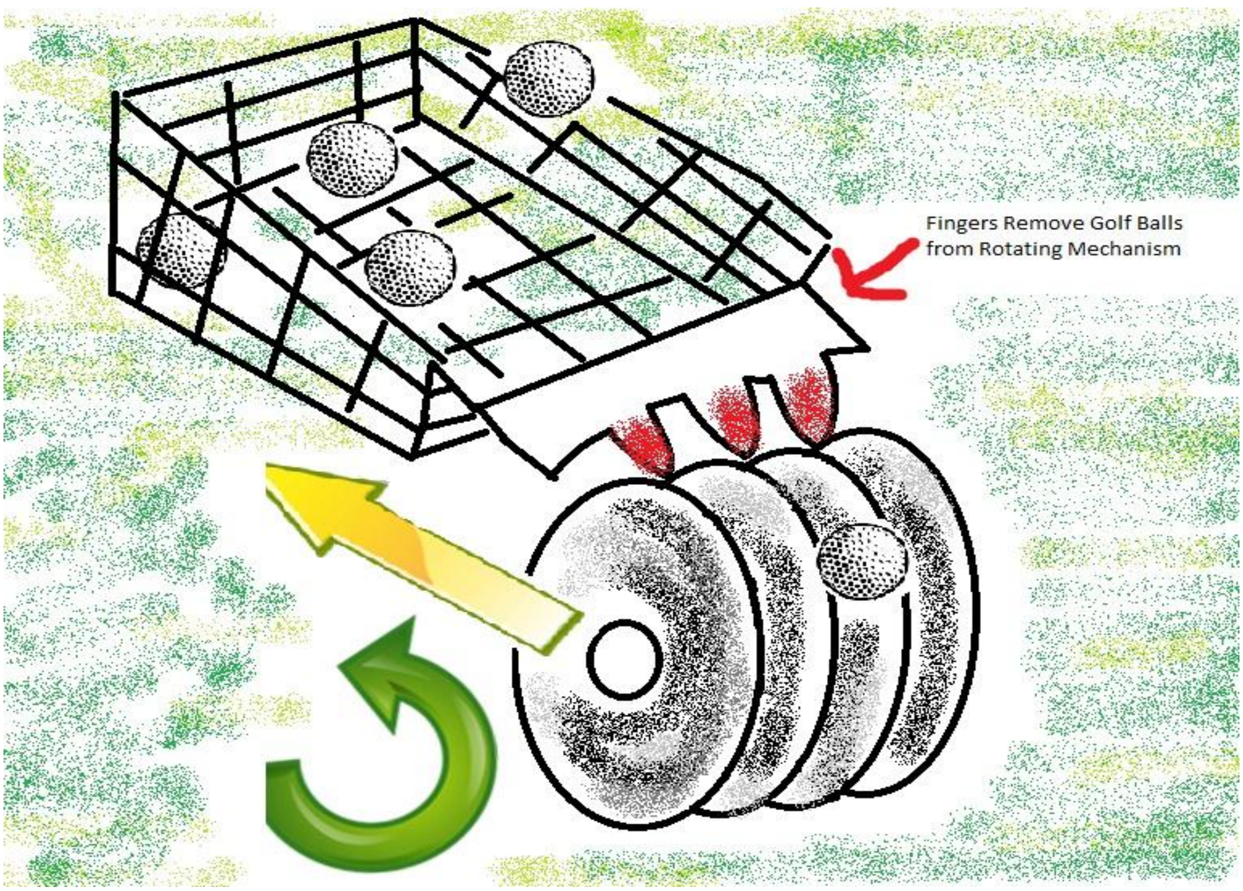

Figure 1: Axial retrieval mechanism for golf balls

2. Design

2.1 Block Diagram

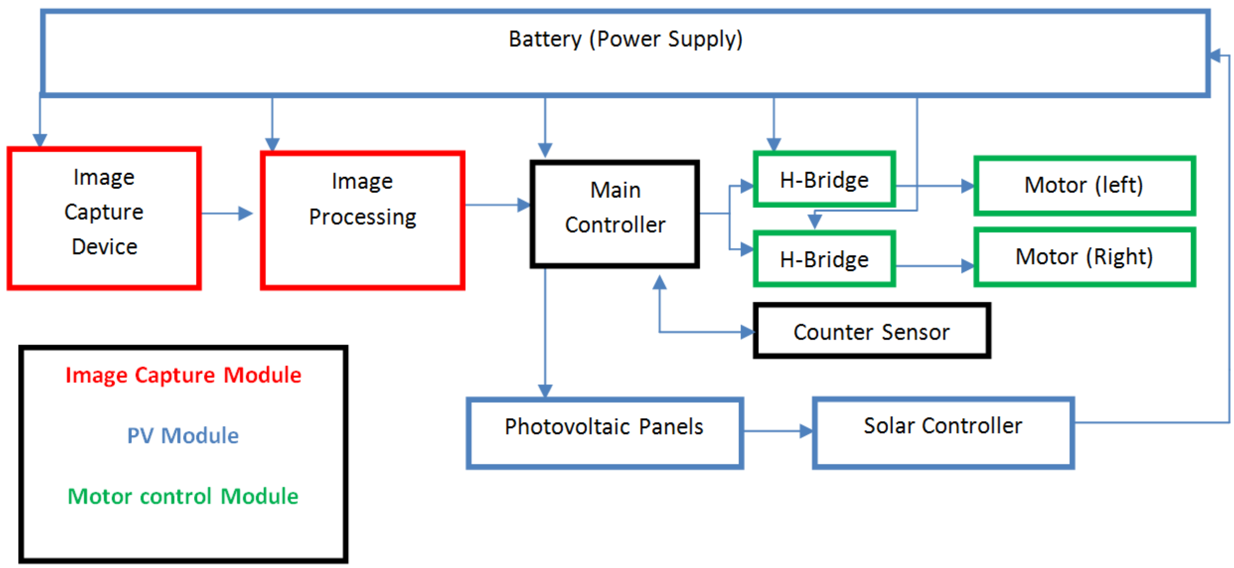

Figure 2: Block diagram of electrical systems

2.2 Block Descriptions

Image Capture Module:

Image Capture device

A Camera will be placed near the front of the robot that will collect images of the surroundings. This data will feed into the image processing unit.

Image processing

The single input from the camera will be fed into the image processor. The processor will analyze the vision data by first separating the image into the foreground, consisting of the golf balls and the background, consisting of everything else. Next the nearest ball location will be determined and its estimated position will be outputted to the main controller. The image processor has yet to be determined but will likely be done through a Pandaboard or the NI CVS 1456.

Mechanical Layout Module

Main Controller

The main controller will take the output from the image processor and output the motor speeds to the h-bridges. It will also take in the input from the photo resistor and act as a counter for the number of balls collected.

Counter Sensor

The counter sensor will consist of an LED and photo resistor placed near the ball collection device. When a ball passes between the LED and sensor, it interrupts the photo resistor and causes a voltage drop to be relayed to the controller.

Mechanical Control Module

DC Drive Motors

Each of these motors will be connected directly to the output of the H-Bridge. These two motors are the work horses for the project. They will not only provide the motion to travel from ball to ball but the forward motion produced by these motors will power the ball pick up mechanism described above. Our design requires for the motors to be 12-24V DC motors with enough power to carry a maximum load back from the range. We are currently considering the Dayton 1/30th hp motors for this application.

H-Bridge

The H-Bridge acts as the interface between the microcontroller control signals using PWM, the battery and the DC Drive motors. This block is a combination of resistors, capacitors, mosfets, and drivers in order to control the robots velocity. The H-bridge allows for high current to be fed directly into the motor and acts as a shield against surges from the motor that could destroy the microcontroller.

Solar and Power Module

Photovoltaic panel

The photovoltaic panel works as a solar battery charger. It produces power proportional to the light intensity radiated from the sun. The solar panel takes this light energy and transforms it to electrical energy for the battery. The PV panel will allow the the robot to continue working by extending the battery life.

Solar controller

The solar controller basically connects the solar panel and the rechargeable battery. It would indicate whether the battery is charging or has been charged, it also outputs a signal back to solar panel to tell whether energy needs to be transferred to the batteries.

Battery

The battery is the power source for the entire system. It will be able to be recharged through the use of a power outlet as well as through the solar cells. The battery will most likely be a lead acid battery due to price and the ability to work well with solar power.

2.3 Performance Specifications

Motor Control Module

- Operate within reasonable temperatures at max duty cycle (40degrees C above ambient Temperature)
- Provide control with duty cycle ranging from zero to max
- Provide enough velocity to successfully pick up golf balls
- Move the unit at a minimum of 0.5 mph
- Ability to operate continuously at 90% duty cycle

Image Capture Module

- Be able to identify balls up to 15 feet away from camera
- Ability to locate at least 80% of balls within cameras field of vision
- Can correctly locate closest ball at least 70% of the time
- Camera will provide at least 15 fps at a resolution of at least 640 x 480

Solar and Power Module

- Batteries/PV array should have enough capacity to provide at least 2 hours of non stop power on a sunny day
- Protective cover to prevent solar panel damage from external sources.
- Should be able to withstand under all weather conditions.

3. Verification

H-Bridge Motor Driver Testing

- Operate at max duty and use thermocouple to determine casing temperature

- simulate duty cycles from zero to maximum to simulate motor controls given by microcontroller PWM
- Voltage is monitored which will be given to motors at forward and backward implementation to ensure safe connection to motor

Full Motor Testing

- Measure Current at various Duty cycles to ensure safe working conditions for microcontroller connection

Image processor testing

A monitor will hook up to the image processor that will display the balls as one color and the background as another color. At least 80% of the balls will show up and will remain detectable within 15 feet. The closest ball will be identified by a different color at least 70% of the time and its center of mass will be displayed on screen by a dot. the image will also have the desired resolution and fps.

Solar system testing

This will be tested to ensure controller shows whether two battery have been charged, and which one is being used or charging. The solar panel will be tested to figure out how long it takes to charged completely. The battery will be tested by allowing the robot to charge completely and then letting the robot collect balls for at least two hours during a sunny day.

4. Cost and Schedule

Labor Cost

Name	Rate	Hours	Hours*2.5	Total ($)
Jonathan Hall	$35.00/hr	240	600	$21,000
Diyang Qiu	$35.00/hr	240	600	$21,000
Kevin Dluzen	$35.00/hr	240	600	$21,000

			Total:	**$63,000**

Parts Cost

Part	Quantity	Unit Cost ($)	Total ($)
Image processing board	1	300.00	300.00
Camera	1	100.00	100.00
Golf Balls	30	0.75	22.50
DC Drive Motors	2	300.00	600.00
H-Bridge Components	2	40.00	80.00
Wheels and Hubs	2	25.00	50.00
Motor Coupling	2	20.00	40.00
Mechanical Frame/Parts	1	500.00	500.00
Solar Panel	1	100.00	100.00
Light Sensor	1	2.00	2.00
Microcontroller	1	35.00	35.00
Battery	2	20.00	40.00
		Total:	**$1869.50**

Total cost = $63,000 + $1869.50 = **$64,869.50**

Schedule

Week	Kevin Dluzen	Diyang Qiu	Jonathan Hall
2/6	Write up proposal		
2/13	Research cameras/CVS	Research Battery/solar panals	Research motors/H-bridge
2/20	Prepare for design review and retrieve major parts		
2/27	Code CVS to recognize balls	interface battery with solar cell	Complete H-bridge
3/5	get CVS to output to microcontroller	Power system design	Interface motor control with microcontroller
3/12	Prepare individual progress report		
3/19	Spring Break		
3/26	Test/debug image capture module	Test/debug solar and power module	Test/debug mechanical control module
4/2	Build mechanical chassis and integrate systems together		
4/9	Finish all system integration and have all components added		
4/16	Prepare for demo and finish testing and debugging of entire robot		
4/23	Write final report and prepare for presentation		
4/30	Finish report, disassemble robot and final checkout		