Lab 3: Touchless Electronic Lock

Introduction

There are many kinds of electronic locks using keypads, finger prints, retina scans, or voice recognition, but this lab will create one using hand motions. Using an IR distance sensor commonly used in robotics, we will measure the distance from the sensor to your hand. Three correct hand positions will open the door.

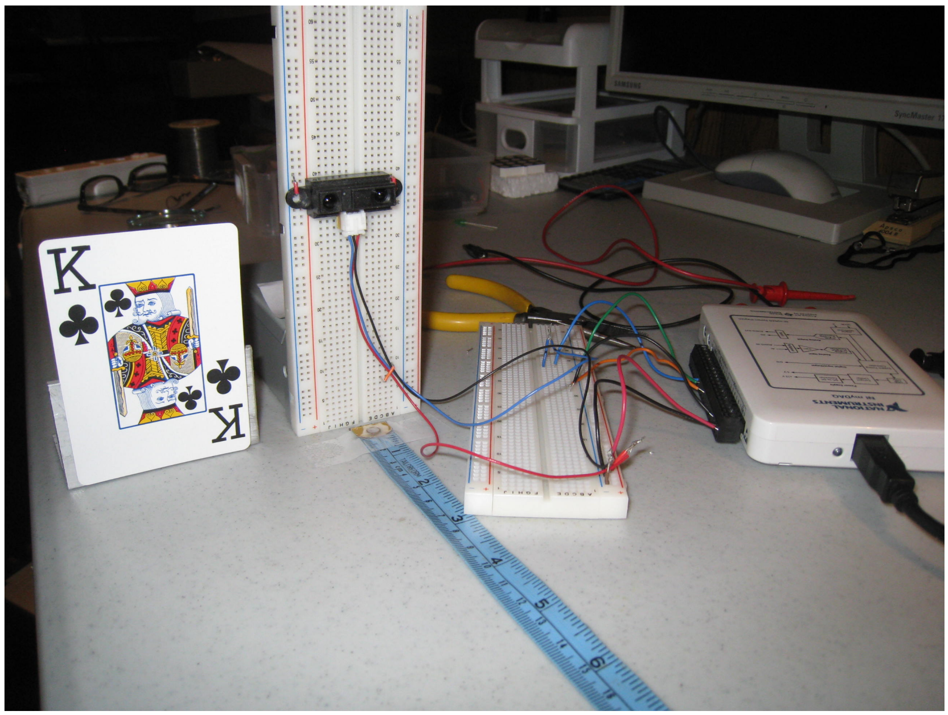

Fig. 1 Components for Optical Measurement of Distances

Purpose

This lab uses a Sharp GP2Y0A21YKOF Distance Measuring Unit (Fig. 1) to measure a hand location in the range of 10 to 50 cm from the sensor face. NI myDAQ digital voltmeter DMM(V) is used in the sensor study. The DAQ Assistant is configured as a voltmeter and embedded in a LabVIEW program for the 'Touchless Electronic Lock'.

Equipment

- NI myDAQ
- Sharp GP2Y0A21YKOF Sensor: www.sparkfun.com
- Recommended: 3-pin JST and JST connector (found at bottom of sensor's webpage)

- Solderless Breadboard

Prerequisite Reference Materials

How to use the NI ELVISmx Digital Multimeter DMM(V):
http://decibel.ni.com/content/docs/DOC-12937

Exercise 3-1: Getting Started

The first step is to observe the operation of the Sharp distance measuring unit. The sensor comes with a three-wire interface

Red wire: + 5 volts connected to myDAQ 5 V socket
Black wire: Ground connect to myDAQ DGND socket
Blue wire: Signal voltage (3.5 to 0.4 V) connected to oscilloscope

Connect ports AI 0+ and AI 0- to the sonar sensor signal (blue) and GND (black) wires. [Run] the oscilloscope continuously in auto range. Move your hand back and forth to get an idea of the sensor range and what voltages occur at these points.

Sensor Calibration

You need to know the specifications for your sensor. You can check the web for the sensor data sheet, but ultimately you will need to verify the sensor response for your own application. For example, the sensing beam size is about the size of a grapefruit at maximum distance of 80 cm, but is considerably smaller at minimum distance of 10 cm. The target size will depend on the distance measured. Reliably validating the sensor cries out for a controlled experiment from which you can generate a calibration curve of *sensor voltage* versus *distance* from your sensor to the target.

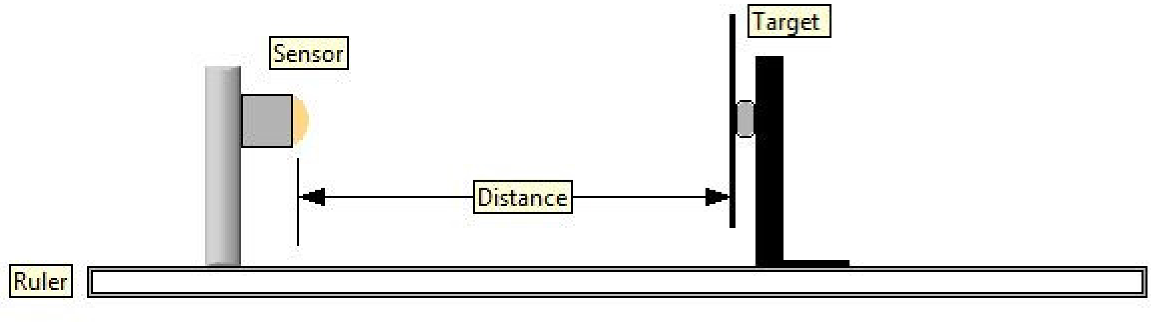

Fig. 2 Calibration Setup

Place the sensor on a breadboard and mount it about 9 cm above the tabletop. Affix a centimeter (cm) scale to the table. Place a reflecting card as a target (15 x 15 cm) on an L-bracket. Place all of these items in a line, as shown in Fig. 2.

The manufacturer's specifications show that the response curve is very nonlinear, so I recommend using the sensor only in its useful range from 6 to 80 cm. The peak around 6 cm (Fig. 3) is the beginning of the useful range.

Fig. 3 Manufacturer's Specifications: Output Voltage vs. Distance

Place your sensor at various distances and measure the sensor voltage. Measure about 20 values from 6 to 80 cm. Record the sensor voltage and distances. Plot a graph of the sensor voltage versus distance to the target screen.

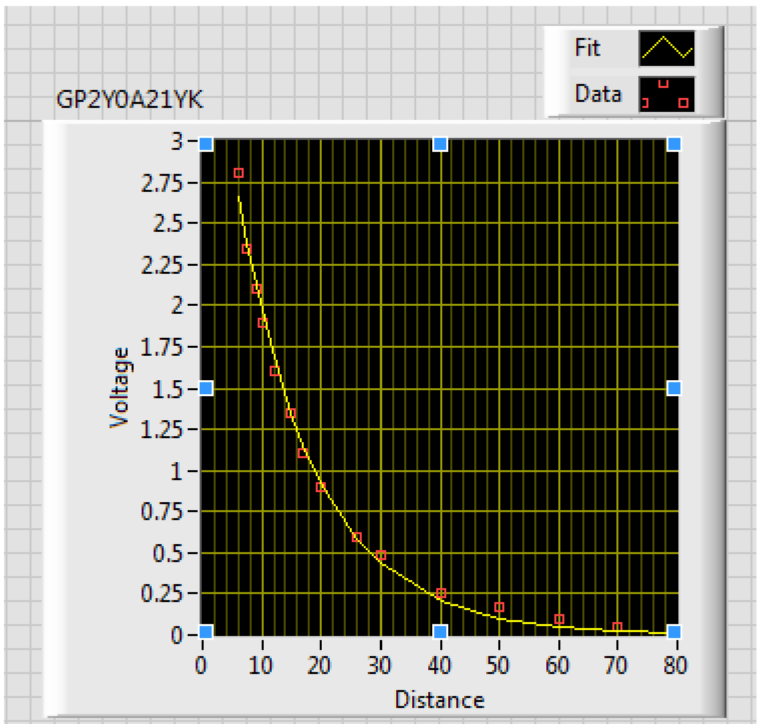

Fig. 4 LabVIEW Graph Output: Voltage vs. Distance for a Real Sensor

Note: Use the program Plot Sharp Sensor.vi to fit data.

The distance sensor follows an exponential decay for D > 6 cm.
The sensor voltage can be expressed as

$$V = 0.4 + \mathbf{A} \exp(-\mathbf{b}D)$$

where 0.4 is the offset voltage and (**A** and **b**) are the fitted values for the amplitude and damping coefficients.

The distance D is calculated from the measured voltage using the equation

$$D = (1/-\mathbf{b}) \ln\{(V - 0.4)/\mathbf{A}\}$$

Automated Distance Measurement

To automate the voltage (distance) measurement, turn to LabVIEW. Open the LabVIEW Student Edition and select a blank VI. Click on the block diagram.

Note: DAQ Assistant is found in Functions/Measurement I/O/NI–DAQmx/DAQ Assistant.

Click and drag the DAQ Assistant icon onto the block diagram.

Select Acquire Signals/Analog Input/Voltage/aio, and then click on the [Finish] and [OK] boxes.

The sensor voltage is connected to AI 0+ (blue lead) and AI 0- (black lead).

Note: By default, the DAQ software selects a sample rate of 1000 samples per second and 100 samples. Therefore, these samples are collected over a 1/10th of a second time interval.

Now add an indicator called Wall to the DAQ Assistant output.
[Run] your program to view the sensor voltage. Save this program.

Open and review the LabVIEW program entitled Get Voltage.vi (see Fig. 5).

To compute the average value of the 100 readings, a DDT icon converts the dynamic data type into a floating point array of measured voltages. The array functions ‘Add Array Elements’ and ‘Array Size’ are used to compute the average value.

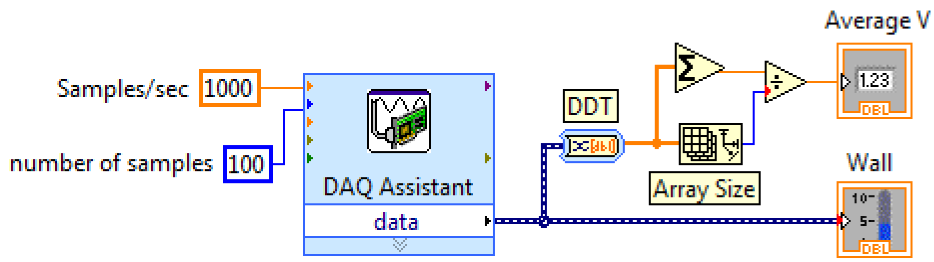

Fig. 5 Block Diagram of Get Voltage.vi

Place the sensor up against a wall and use your hand as a target.

Run the program Get Voltage.vi continuously to get a feel for the voltage range as you move your hand in and away from your shoulder.

Now, let's add the sensor calibration to convert the measured voltage into a measured distance.

Open and review the LabVIEW program entitled Get Distance.vi.

It is similar to the previous program, except a subVI (Volt to Distance.vi) has been added. Click on the subVI to see how the above conversion equation has been coded.

Run the program Get Distance.vi to get a real world feel for the sensor operation.

Exercise 3-2: Automatic Door Opener

Adding a compare function to our Distance program turns our sensor into a proximity sensor. If the distance is, say, less than 40 cm, then it will open the door. Otherwise it will repeat the measurement. In LabVIEW, this feature is coded by the 'Less than?' function (Fig. 6).

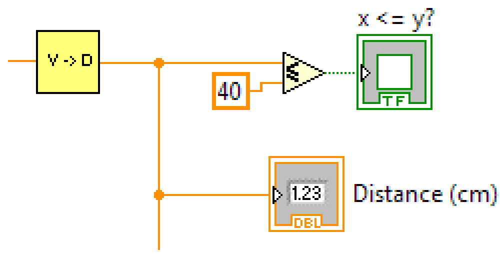

Fig. 6 LabVIEW 'Less than?' function Added to Get Voltage.vi

Now, suppose a secret compartment is to be opened only when your hand is placed in a unique location, say 30 cm in front of our sensor. The

LabVIEW function ‘In Range?’ comes to our aid (Fig.7). The output is only true when the input signal is between a lower and an upper limit.

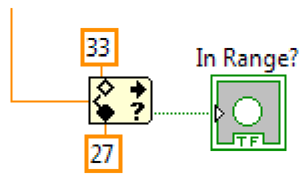

Fig. 7 LabVIEW ‘In Range?' Function Added to Get Voltage.vi

Open and run the LabVIEW program entitled Get Location.vi and observe how it works.

Look at the front panel:

- The rectangular box on the front panel changes color from white to yellow when the target hand is less than 40 cm away.
- A disc indicator changes color from white to red when the distance measured is between an upper (33 cm) and a lower (27 cm) limit.

Imagine how you could use such a sensor with a LabVIEW program to

- Unlock you dorm door
- Turn on a mood light
- Set off an alarm whenever the refrigerator door opens.

In later labs, we will show you how to control LEDs, relays, and motors.

Exercise 3-3: Touchless Electronic Lock

Most electronic locks require three or more numbers/positions to open. Your hand and the sensor become a pointer whose length is a position or a number. The ‘Touchless Electronic Lock’ requires you to place your hand in three successive correct locations. Then the lock will open.

How Did They Do That?

Step 1: You must calibrate your hand with the sensor to a unique position, thereby defining a starting measurement point. A LabVIEW program with feedback, such as Get Zero.vi, can provide such an indicator. A unique location (say 30 cm) is the sensor's zero or origin of future measurements. Once the zero point is established, the unlock procedure can be started.

Open the LabVIEW program Get Zero.vi and view the front panel.

This program will guide you to a location to begin the unlock sequence. Indicators will flash 'Too Close' or 'Too Far'. Once the origin position is reached, the program's OK indicator will turn green, and the program will stop.

The three indicators (Too Far, Too Close, and OK) change colors when the hand measurement falls into their region. To ensure the hand is held at the correct position, the OK region must be held for 1 second. The zero position is then set.

Look at the block diagram (Fig. 8) to see how this implemented.

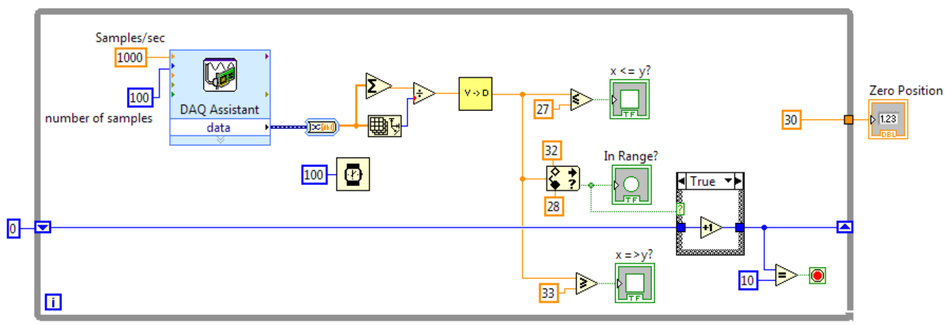

Fig. 8 Get Zero.vi Requires Hand in Correct Location for 1 Second to Define the Zero Position

Note: make sure the DAQ Assistant is using the correct device port for all subsequent lab exercises (DAQ Assistant→Configuration→Add More Channels→Select correct channel and delete old one→Ok).

Step 2: Open and review the LabVIEW program (Fig. 9) called Unlock.vi.

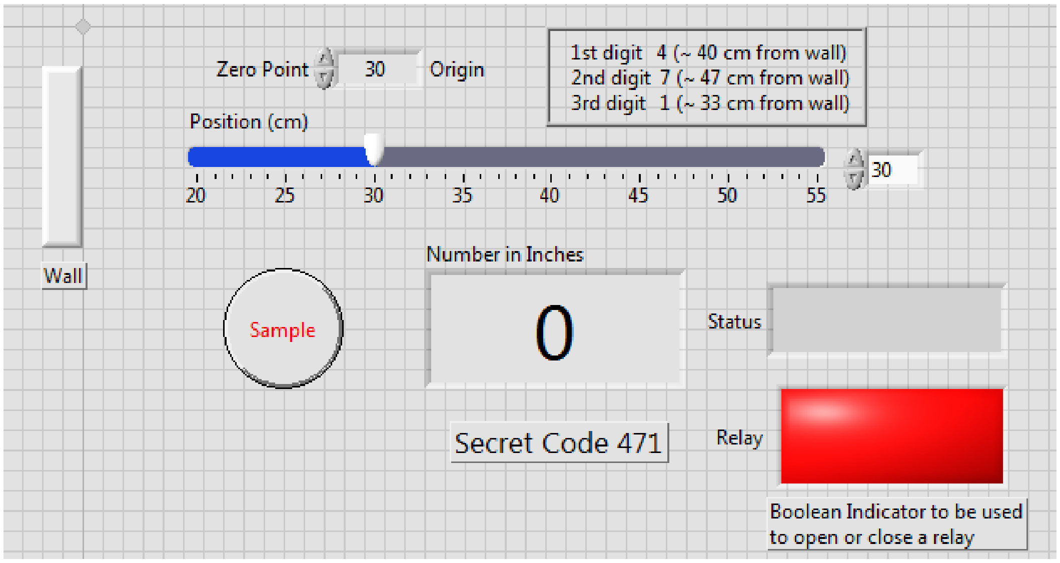

Fig. 9 Simulator to Demonstrate the Touchless Door Lock Operation

This program simulates how the lock could work. The zero point location is a constant (30 cm), but in a real program, it would come from the Get Zero.vi. The current hand position, shown as a slider in Fig. 9, would come from the Get Location.vi in a real program. Run the program and use the slider to simulate the movement of your hand. When you are ready to input a number, press the [Sample] button. The current position rounded off to the nearest inch is shown in the display. After three numbers, the program will reveal the lock status. Test the measured locations with the secret code provided, or make your own. If a match is found the lock will open.

Note: The hand position is measured in inches from the zero point. It is easier to move your hand in inch increments rather than centimeter increments.

Open and view the block diagram to see how it works.

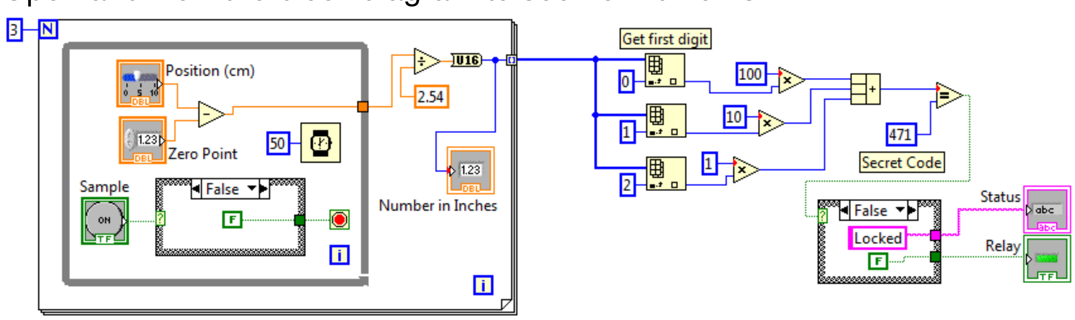

Fig.10 Unlock.vi Block Diagram

The current hand position is given by the measured location minus the zero position. When the [Sample] button is pressed, the current location is converted into inches, rounded off to the nearest integer, and stored in an array on the for loop. After three samples, the array is reversed (so the first element is the first code digit). The array elements are converted into a three digit number and compared with the secret code (471). The lock status appears as a Boolean indicator and a string message ‘Locked’ or ‘Unlocked’.

LabVIEW Challenge Modify the two programs Get Zero.vi and Unlock.vi to form a new program that uses the distance sensor and your hand waves to unlock the door.

