



# Arduino Based 3D Touchless Interface

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**Abstract:** The whole project is based on the idea on length of time it takes a capacitor to charge, based on this charging time the distance and other related values and coordinates are measured and the motion path is calculated. The main objective of the project is Touchless 3D tracking, as the name suggests the project focuses on detection of 3D motion without any external touch and replicate the same motion on our computer screen. That is, the computer should be able to detect the entire motion path of the desired object. The Tracking takes place in 3 Dimensional field that is x,y and z, that is the depth is also taken into consideration. Each axis acts like a capacitor when the voltage is applied to it. As our hand approaches the plate our body electrically couples with the plate and changes its capacitance. The higher the capacitance the longer it will take for the capacitor to get fully charged. The software on the Arduino measures the time it takes to charge the plates. The change in the charge time corresponds to the hands distance from the plate. The Whole project is based on Arduino Micro-controller, which is an open source microcontroller. The project will be implemented on Arduino platform, which provides direct interaction with the Arduino micro-controller. The simplicity of this 3D tracking mechanism will show us, what all are the possibilities for future and what all can be achieved using some simple and logical techniques.

**Keywords:** Arduino, Touchless Interface, Micro Controller, Capacitive Sensing

## I. INTRODUCTION

Our project is based on the idea of length of time taken by a capacitor to charge, based on this charging time the distance and other related values and coordinates are measured and the motion path is calculated. The project focuses on detection of 3D motion without any external touch and replicates the same motion on our computer screen. That is, the computer should be able to detect the entire motion path of the desired object. Capacitive sensing is explored by using several panels of cardboard lined with aluminium foil. These boards, when charged, make electric fields that compare to X, Y, and Z pivot to make a 3D square. With the guide of an Arduino microcontroller and some provided code, developments inside the 3D square are followed as your hand moves around inside the field. The whole project is based on Arduino Micro-controller, which is an open source microcontroller. Each axis acts like a capacitor when the voltage is applied to it. As our hand approaches the plate, our body electrically couples with the plate and changes its capacitance. The higher the capacitance the longer it will take for the capacitor to get fully charged. The software on the Arduino measures the time it takes to charge the plates. The change in the charge time corresponds to the hands distance from the plate.

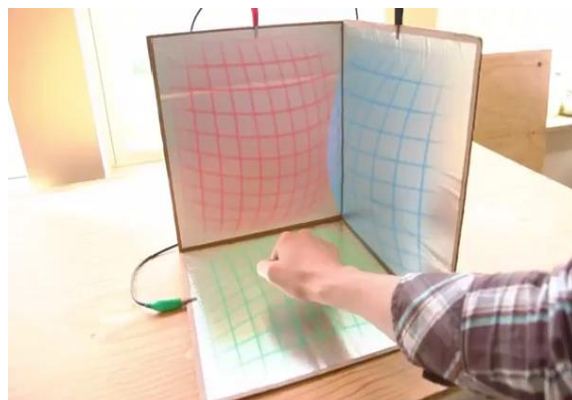


Fig 1: Model of the project

## II. MOTIVATION OF THE WORK

This project is indirectly related to touch screens and can be seen at its next level. Every modern gadget we have today comes with a touch screen, be it a mobile or a camera or any digital device. Touch screen is a very current and evolving technology, and any work related to this will definitely be of much relevance in the present era.



The touch screens itself are of two types- Capacitive and Resistive. While capacitive is the more preferred one due to its smooth and flowing interface but a resistive one needs to be there for any kind of stylus interaction. It's hard to believe that just a few decades ago; touch screen technology could only be found in science fiction books and film. These days, it's almost unfathomable how we once got through our daily tasks without a trusty tablet or smart phone nearby, but it doesn't stop there. Touch screens really are everywhere. Homes, cars, restaurants, stores, planes, wherever—they fill our lives in spaces public and private. The main feature which motivated me for making this project was to create something useful by using simple materials and circuitry. I'm well aware there are better ways to do capacitive distance sensing, but I wanted to make something as simple as possible that's still functional.

### III. PROJECT ANALYSIS

The project uses the concept of capacitive sensing. It is based on a very simple idea of the time taken by the capacitor to charge and using this concept, a 3D interface is created. Nearly all sensing of this kind depends upon how long it takes a capacitor to charge (known as the time constant). Placing an object within the electric field of a capacitor will affect the capacitance value and the corresponding time constant.

#### (A) Phenomenon of capacitive sensing

Capacitive sensors allow measuring the distance between an electrode and other objects. The electrode creates an electric field that is disturbed by objects passing through it. The amount of disturbance is determined by the electric properties of the object and its distance to the electrode. The range of such a sensor can be from micrometers to a couple of meters, depending on sensor design and electrode size. The resolution can be up to a few nanometres, but generally rapidly decreases with distance between electrode and object. The simplest capacitor consists of two metal plates which are close to another without touching each other. When a current is placed on those plates, the arrangement can store energy. When the current is removed and the plates are connected through a circuit, the stored energy initiates a current.

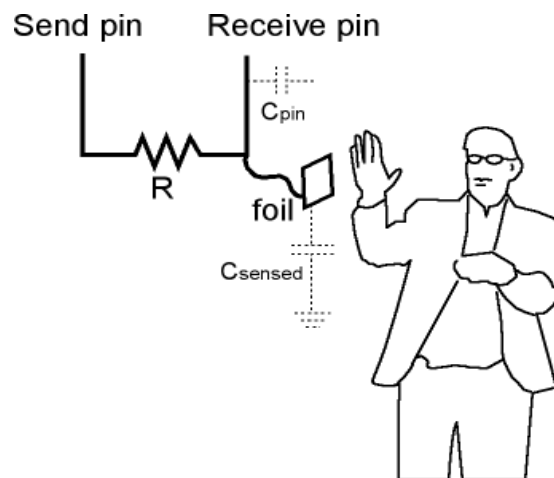


Fig 2: Phenomenon of capacitive sensing

Thus, a capacitor works like a small accumulator. The capacity (capacitance) of a capacitor depends on the size of the plates and their distance. When the distance between the plates is increased, the capacity of the capacitor decreases. There is great variety on other technologies for realizing capacitive electrical elements as well. Similarly, there are various ways how to measure the capacity of an capacitor. A simple option is to use an electric circuit consisting of a resistor and a capacitor. Measuring the time till a certain voltage is reached (charging) can be used to calculate the capacity if the voltage and the value of the resistor is known. Using the above mentioned effect, one can measure and track the distance between a sensor and an object. For this, one of the two plates of a capacitor is replaced by the object to be tracked. In order to hold enough free electrons, the object has to have a relatively high dielectric constant. Most of these materials are electrically conductive like metal, water or the human body. When the object gets closer to the plate, the capacitance of this pseudo capacitor increases. One can measure the capacitance of this capacitor and from this estimate the distance between sensor plate and object. No current has to be applied to the object as it should provide enough free electrons. A connection to ground can increase the amount of free electrons, however. The most common way to measure the capacitance of a capacitor is to use a resonant circuit. Depending on the capacitor's capacitance, the resonant circuit resonates faster or slower. This technique of measuring distances between a sensor and an object is called Capacitive Sensing. Such sensors allow even measurement of microscopic displacements in the range of micrometers. They are the industry standard for ultra-high precision measurements in many application However,



Capacitive Sensing can also be used to track objects, e.g. the human hand as electrically conductive object, in larger ranges. The feasibility of using Capacitive Sensing for position and gesture input to enable intuitive human-computer interaction is the main contribution of this work. Capacitive sensors offer High Robustness- Capacitive sensors have no moving or fragile parts. The sensor itself is a small circuit board, the electrode is usually a sturdy metal plate. Thus they can be incorporated into installments or play objects.

They exhibit Variable Sensor Characteristics- Capacitive sensors are very versatile. Their primary use is for proximity sensing. The sensitivity and direction of the sensor is determined by electrode size, shape and placement. Instead of generating a lot of data (like e.g. a camera) requiring costly post-processing, capacitive sensors just deliver the data you defined by sensor design and placement. They can even be used to measure capacitive coupling between human body and ground, detecting a user's hand or foot motion.

Capacitive sensors have a wide variety of uses. Some are :

- Flow--Many types of flow meters convert flow to pressure or displacement, using an orifice for volume flow or Coriolis effect force for mass flow. Capacitive sensors can then measure the displacement.
- Pressure--A diaphragm with stable deflection properties can measure pressure with a spacing-sensitive detector.
- Liquid level --Capacitive liquid level detectors sense the liquid level in a reservoir by measuring changes in capacitance between conducting plates which are immersed in the liquid, or applied to the outside of a non-conducting tank.
- Spacing--If a metal object is near a capacitor electrode, the mutual capacitance is a very sensitive measure of spacing.
- Scanned multiplate sensor--The single-plate spacing measurement can be extended to contour measurement by using many plates, each separately addressed. Both conductive and dielectric surfaces can be measured.
- Thickness measurement--Two plates in contact with an insulator will measure the insulator thickness if its dielectric constant is known, or the dielectric constant if the thickness is known.
- Ice detector--Airplane wing icing can be detected using insulated metal strips in wing leading edges.
- Shaft angle or linear position--Capacitive sensors can measure angle or position with a multiplate scheme giving high accuracy and digital output, or with an analog output with less absolute accuracy but faster response and simpler circuitry.
- Lamp dimmer switch--The common metal-plate soft-touch lamp dimmer uses 60 Hz excitation and senses the capacitance to a human body.
- Keyswitch--Capacitive keyswitches use the shielding effect of a nearby finger or a moving conductive plunger to interrupt the coupling between two small plates.
- Limit switch--Limit switches can detect the proximity of a metal machine component as an increase in capacitance, or the proximity of a plastic component by vir-Capacitive Sensors tue of its increased dielectric constant over air.
- X-Y tablet--Capacitive graphic input tablets of different sizes can replace the computer mouse as an x-y coordinate input device. Finger-touch-sensitive, z-axis-sensitive and stylus-activated devices are available.

### (B) Project procedure and working

The schematic circuit diagram of the project is shown as under:

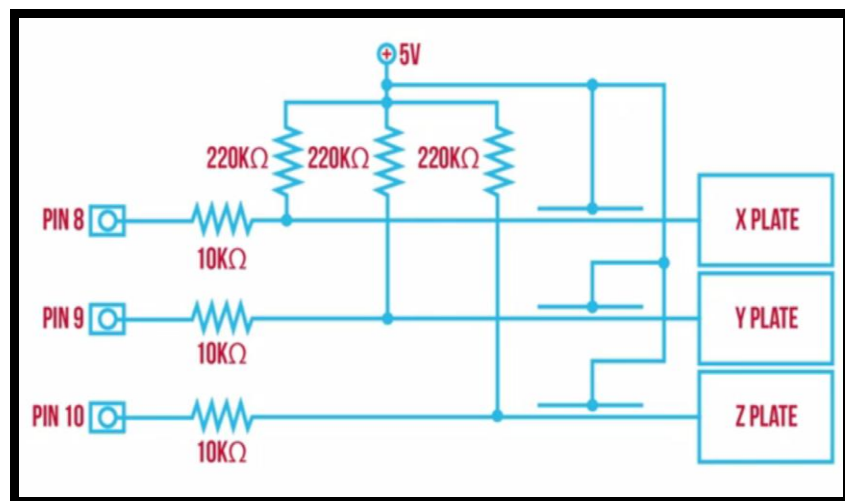


Fig 3: Schematic circuit diagram



Each plate is connected to an arduino pin through a 10k resistor. In addition, each plate will have a 220k pull up resistor. Each plate will be charged and discharged through these resistors. The Tracking takes place in three Dimensional field that is x,y and z, that is the depth is also taken into consideration. The circuit consists of two resistors per panel.

Each axis acts like a capacitor when the voltage is applied to it. As our hand approaches the plate our body electrically couples with the plate and changes its capacitance. The higher the capacitance the longer it will take for the capacitor to get fully charged. The software on the Arduino measures the time it takes to charge the plates. The change in the charge time corresponds to the hands distance from the plate. Since the resistors are fixed, a change in capacitance will be measurable. The distance from ground (your hand) will be the primary variable contributing to the capacitance. Nearly all sensing of this kind depends upon how long it takes a capacitor to charge (known as the time constant). Placing an object within the electric field of a capacitor will affect the capacitance value and the corresponding time constant. The RC time constant, the time constant (in seconds) of an RC circuit, is equal to the product of the circuit resistance (in ohms) and the circuit capacitance (in farads), i.e.  $\tau = R \times C$ . It is the time required to charge or discharge the capacitor, through the resistor, by  $\approx 63.2$  percent of the difference between the initial value and final value. This value is derived from the mathematical constant e, specifically  $1 - e^{-1}$ .

Three helpful things that the Tic Tac Toe code demonstrates:

- Linearizes the raw data. The charge time actually follows a power law relative to distance, so you have to take the square root of one over the time (i.e., distance  $\sim \sqrt{1/\text{time}}$ ).
- Normalizes the data. When you start up the sketch, hold the left mouse button down while moving your hand around to define the boundaries of the space you want to work with.
- Adding "momentum" to the data to smooth out any jitters.

#### IV. SYSTEM SPECIFICATION

##### (A) Hardware requirements

This project requires the following hardware components :

Arduino Uno microcontroller

USB cable

Computer System

##### Arduino microcontroller

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing).

##### Why Arduino?

There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

- Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand.

Cross-platform - The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

Simple, clear programming environment - The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with the look and feel of Arduino

Open source and extensible software- The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand



the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

Open source and extensible hardware - The Arduino is based on Atmel's ATMEGA8 and ATMEGA168 microcontrollers. The plans for the modules are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

### Arduino UNO :

The Arduino Uno is a microcontroller board based on the ATmega328 . It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.



Fig 4: Arduino uno microcontroller

### Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

### (B) Software requirements

The following software are required:

- Arduino development environment
- Processing software

### Arduino software

The Arduino development environment contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. This can be downloaded from website "arduino.cc".

### Writing sketches

Software written using Arduino are called sketches. These sketches are written in the text editor. Sketches are saved with the file extension .ino. It has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino environment including complete error messages and other information. The bottom righthand corner of the window displays the current board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.



V. SNAPSHOTS

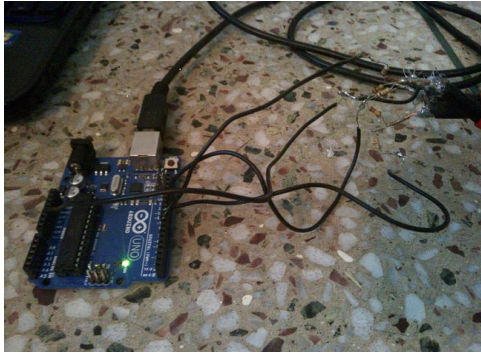


Fig 5: Arduino connections



Fig 6: Sensor cube connected to Arduino



Fig 7: Project demonstration

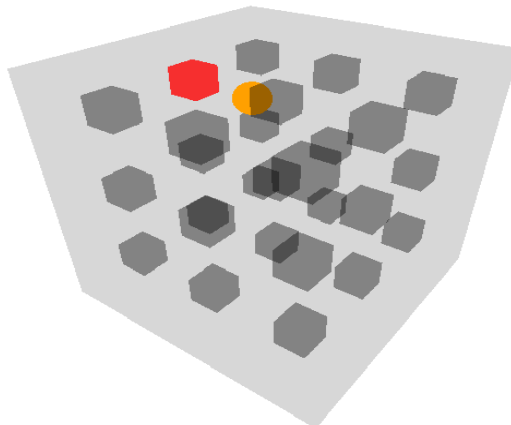


Fig 8: Cube schematic on computer screen

V. CONCLUSION

The modern age of electronics is turning everyone into royalty. We have court jesters (TV), scholars (computers), and scribes (office software) at our command. Soon, these servants will even be watching our slightest gestures and voice commands to heed our will. Hitachi announced its TV with gesture controls more than a year ago. Though the specifics differ among devices, each of these technologies would allow a user to simply gesture commands to their electronics. Change volume, browse through movies, or drive an arcade race car...all you need is your hands. 3D tracking is not a new idea and has been around for quiet some while now. But in the past 5 years the use of touch interface has developed so much that we need superior motion sensing and understanding capabilities to enhance and evolve the technology further. And gesture technology itself is part of an even larger trend – the changing nature of the computer-human interface. Remotes, keyboards, mice, or game pads, most electronics translate button pushes into commands. The new paradigm for control will be one where our natural movements are harnessed to form a more intuitive way of



expressing our desires to our devices. Wave your hand dismissively to change a channel, shake your phone to end a call, or play with blocks that represent files you want to move around. Eventually we'll remove the physical interfaces altogether. The simplicity of this 3D tracking mechanism will show us, what all are the possibilities for future and what all can be achieved using some simple and logical techniques. 3D Touchless tracking tracks the motion of hands in 3 Dimension, in future these type of technologies can be used for remote surgical procedures, robot arms, simulators and for playing highly interactive games. This type of technology can be used for controlling a whole range of next generation devices through gestures.

#### Variations

- Optimize the resistors and code for things that vibrate quickly, and use it as a pickup/microphone
- Remote surgical procedures
- Robot arms
- Build massive sensors
- Playing highly interactive games
- Make an RGB or HSB color picker
- Control video or music parameters; sequence a beat or melody
- Large, slightly bent surface with multiple plates + a projector = "Minority Report" interface

The overall trend towards intuitive controls, however, is something we can count on. The growing popularity of touch screens and accelerometers in smart phones is just one sign that consumers want a more natural way to command their personal electronics. We want our digital servants to not only know what we are thinking, we want them to be obedient to the exact details of our order. One day, devices will directly translate our thoughts into commands. Until then, we're likely to see many efforts to create an intuitive and friendly set of controls for the technology around us.

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