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# Temperature and Humidity Sensor Based Air Blower Controller For Food Drying

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**ABSTRACT**

The food industries throughout the world have a lot of drying processes. In this project, a temperature and humidity based air flow control mechanism is proposed. In an airtight closed box where a particular wet food in placed, this process can be applied. A lot of foods required to not to be heated beyond a certain temperature to maintain their molecular integrity and nutrient value. At the same time, their moisture content has to be reduced to a certain level for preservation purpose. This demands, different food types to be dried for varying time duration, based on their moisture content. This system senses the humidity and the temperature and controls the airflow mechanism by varying the blower fan speed accordingly.

**Keywords**: **Arduino, Sensors, Drying**

## 1. Introduction

The presence of moisture and humidity in any part of the food production cycle can mean the difference between a product being safe and fresh versus unsafe and spoiled. Moisture often leads to the growth of bacteria, mildew, or mold. Condensation on cold products also creates moisture risks when storing food. Fortunately, these risks can be easily mitigated by using temperature control technology and dehumidification systems. This project presented here is a temperature and humidity based airflow control mechanism. This idea can be applied for the food, which is placed in an airtight closed box. Furthermore, when a food product is considered there will be many more restrictions like it should not be heated or condensed beyond a particular temperature and should maintain a proper molecular integrity and nutrient value and at the same time to avoid food spoilage, some moisture content should be reduced to a certain level. Here this speaks about the different food items at which temperature it should be dried or processed. This senses humidity and temperature, which controls the airflow mechanism by varying the blower fan speed accordingly.

## 2. Proposed System

The system consists of Temperature and humidity sensor, Arduino UNO, relay and a DC fan. The systems mainly look out for the humidity of the air i.e., the water content in the air. When the threshold limit the fan is spun. For food drying purpose we use a Arduino based air blower. The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. The threshold is set for both humidity and temperature. It is coded in Arduino UNO. When either of the conditions is met, the Arduino enables he fan to start spinning thus cooling the food.

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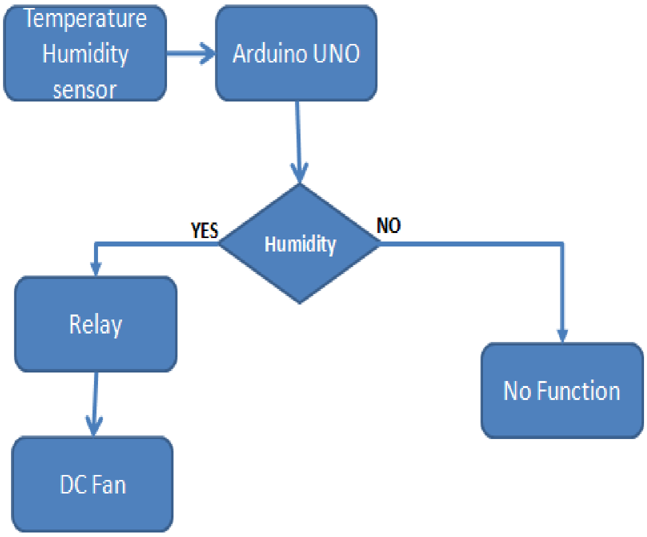


Figure 1. Block Diagram

## 3. Arduino Microcontroller

“The microcontroller used to implement this project and similar projects are Arduino boards. Presented below is an outline of Arduino family boards.”[2]

### 3.1 Introduction

“Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices. It’s hardware products are licensed under a CC-BY-SA license, while software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially from the official website or through authorized distributors”[2]

“Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs. The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the Arduino language. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) and a command line tool (arduino-cli) developed in Go”[2]

“The Arduino project began in 2005 as a tool for students at the Interaction Design Institute Ivrea in Ivrea, Italy, aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats and motion detectors. The name Arduino comes from a bar in Ivrea, Italy, where some of the founders of the project used to meet. The bar was named after Arduin of Ivrea, who was the margrave of the March of Ivrea and King of Italy from 1002 to 1014”[2]

### 3.2 Hardware

“Arduino is open-source hardware. The hardware reference designs are distributed under a Creative Commons Attribution Share-Alike 2.5 license and are available on the Arduino website. Layout and production files for some versions of the hardware are also available”[2]

“Although the hardware and software designs are freely available under copy left licenses, the developers have requested the name Arduino to be exclusive to the official product and not be used for derived works without

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permission. The official policy document on use of the Arduino name emphasizes that the project is open to incorporating work by others into the official product. Several Arduino-compatible products commercially released have avoided the project name by using various names ending in –duino"[2]

"An early Arduino board with an RS-232 serial interface (upper left) and an Atmel ATmega8 microcontroller chip (black, lower right); the 14 digital I/O pins are at the top, the 6 analog input pins at the lower right, and the power connector at the lower left."[2]

"Most Arduino boards consist of an Atmel 8-bit AVR microcontroller (ATmega8, ATmega168, ATmega328, ATmega1280, or ATmega2560) with varying amounts of flash memory, pins, and features. The 32-bit Arduino Due, based on the Atmel SAM3X8E was introduced in 2012. The boards use single or double-row pins or female headers that facilitate connections for programming and incorporation into other circuits. These may connect with add-on modules termed shields. Multiple and possibly stacked shields may be individually addressable via an I²C serial bus. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator or ceramic resonator. Some designs, such as the Lily Pad, run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions."[2]

"Arduino microcontrollers are pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory. The default boot loader of the Arduino Uno is the Optibootbootloader. Boards are loaded with program code via a serial connection to another computer. Some serial Arduino boards contain a level shifter circuit to convert between RS-232 logic levels and transistor–transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods. When used with traditional microcontroller tools, instead of the Arduino IDE, standard AVR in-system programming (ISP) programming is used. An official Arduino Uno R2 with descriptions of the I/O locations. The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits. The Diecimila, Duemilanove, and current Uno provide 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields are also commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside of the board that can plug into solderless breadboards."[2]

"Many Arduino-compatible and Arduino-derived boards exist. Some are functionally equivalent to an Arduino and can be used interchangeably. Many enhance the basic Arduino by adding output drivers, often for use in school-level education, to simplify making buggies and small robots. Others are electrically equivalent, but change the form factor, sometimes retaining compatibility with shields, sometimes not. Some variants use different processors, of varying compatibility."[2]

### 3.3 Software

"A program for Arduino hardware may be written in any programming language with compilers that produce binary machine code for the target processor. Atmel provides a development environment for their 8-bit AVR and 32-bit ARM Cortex-M based microcontrollers: AVR Studio (older) and Atmel Studio (newer)."[2]

IDE:

"The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, and Linux) that is written in the Java programming language. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. The source code for the IDE is released under the GNU General Public License, version 2."[2]

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"The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware."[2]

Pro IDE:

"On October 18, 2019, Arduino Pro IDE (alpha preview) was released. The system still uses Arduino CLI (Command Line Interface), but improvements include a more professional development environment, auto completion support, and Git integration. The application frontend is based on the Eclipse Theia Open Source IDE. The main features available in the alpha release are:"[2]

Sketch:

"A sketch is a program written with the Arduino IDE.[64] Sketches are saved on the development computer as text files with the file extension .ino. Arduino Software (IDE) pre-1.0 saved sketches with the extension."[2]

"A minimal Arduino C/C++ program consists of only two functions:

setup( ):

This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch. It is analogous to the function main ().

loop ( ):

After setup () function exits (ends), the loop() function is executed repeatedly in the main program. It controls the board until the board is powered off or is reset. It is analogous to the function while."[2]

## 4. Industry 4.0

"Wikipedia defines Industry 4.0 as thus: The Fourth Industrial Revolution (4IR or Industry 4.0) is the ongoing automation of traditional manufacturing and industrial practices, using modern smart technology. Large-scale machine-to-machine communication (M2M) and the internet of things (IoT) are integrated for increased automation, improved communication and self-monitoring, and production of smart machines that can analyze and diagnose issues without the need for human intervention."[3]

Automation under Industry 4.0 has a particular schema or pattern at its outset. Presented below is how automation in the mass production industry as well as consumer level products are built in today's technological era.

The schema presented in Figure 2 has a lot of other components involved but the generic outline of it stands justifiable for all kinds of automation today.

The software automaton of the conventional automation model, which is the status quo, was built by a human expert or a team of human experts till now. With the advent of machine learning technology, the software automaton was not fully directly designed by human experts. The human experts build the machine learning software and give the real world data set as training information. The machine learning software identifies the pattern between the input and the output parameters of the dataset in the form of a mathematical model. This mathematical model can be downloaded as a working software module to other electronic computing devices. This mathematical model is referred to as the 'trained machine learning module'. The software automaton of all the current digital embedded devices is a mathematical model that gives a numerical output for a numerical input based on arithmetic and logical conditions. This software automaton, as explained above can be either directly developed by a set of human experts by means of setting the boundary conditions themselves based on observation and requirement or can be downloaded as an executable module from machine learning training systems that are trained with relevant dataset. In whatever way the software

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automaton is developed, it can be loaded onto the relevant embedded computing module that can be used for either sensor based closed loop automation or open loop automation.

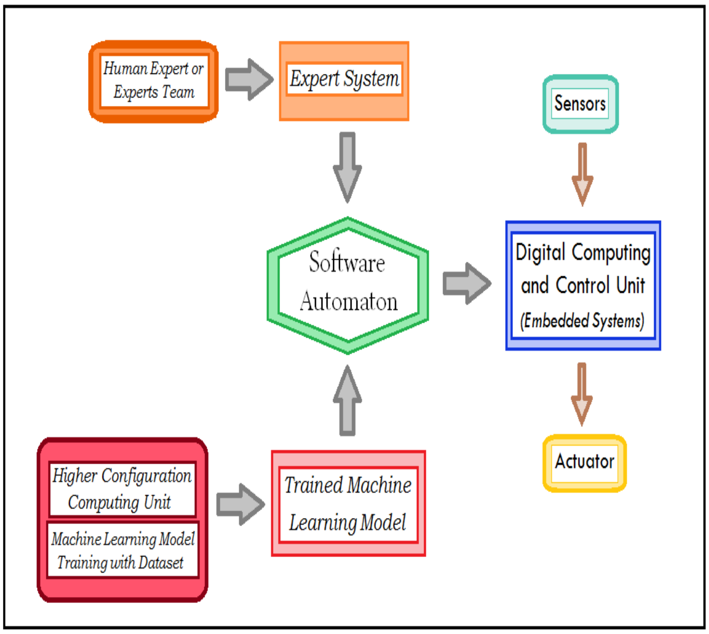


Figure 2. Schema of Automation

The technological components of Industry 4.0 includes IoT, augmented reality, virtual reality, cloud computing, 3D printing, big data analytics, networking, data security, human-machine interaction and others. IoT is a very effective way to collect real world data. Sensors integrated with data acquisition and transmission systems can be placed anywhere and the collected data can be pre-processed if required and used as datasets to train machine learning models.

Cloud computing is employed for optimized utilization of computing resources. There are many third party vendors like Google and Amazon which are very reliable in terms of data security and speed of computation. These services offer companies and organizations a cheap and reliable way to harness the power of artificial intelligence and machine learning.

Big data analytics is the set of technological components involved with collecting, collating and managing large quantities of data for analytics and decision making. When so much data is involved, especially with third party service providers, data security plays an important role.

One of the paramount concerns about Industry 4.0 is the unemployment it can create due to powerful automations. The field of human-machine interactions and co-working has been a very developing field now to mitigate the above mentioned problem.

## 5. Working

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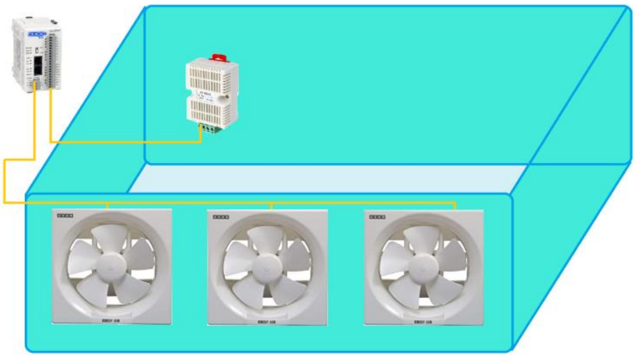

Figure 3. Schematic Diagram

Presented above is the schematic diagram (Figure 3) of a closed container that can house food products. Three exhaust fans are fitted on one side. The temperature and humidity sensor is fitted inside the box. The readings of the sensor above mentioned is sent to the microcontroller placed outside. Based on the readings and the automaton loaded in the microcontroller, the three fans are actuated with a required RPM, according to which the vapourized moisture content is pushed out of the box. This system is suitable for solar drying of foods.


Figure 4. Firewood Food Drying

Figure 5. Electrical Food Drying

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Presented above are two images of firewood based and electrical food drying systems (Figure 4 and 5). The system presented in this paper is mainly for open drying systems.

## 5. Results And Discussion

As shown in the Figure 6 and Figure 7, the circuit of the system consists of a temperature and humidity sensor, an Arduino Uno board and an exhaust fan. This is an ideation level prototype of the product presented in this paper. The industrial grade prototype of this product will have a very similar setup as above. There are various qualities of temperature and humidity sensors with varying accuracy and robustness. The difference will be that more industrial grade components will be used. This circuitry was tested and the performance was satisfactory in terms of validating the proposed method. In the industrial grade prototype this system can be integrated with an IoT module and the data will be transmitted to the cloud computing enabled server. Analytics can be performed on the collected, collated and pre-processed data for obtaining useful inferences of the system and the environment.

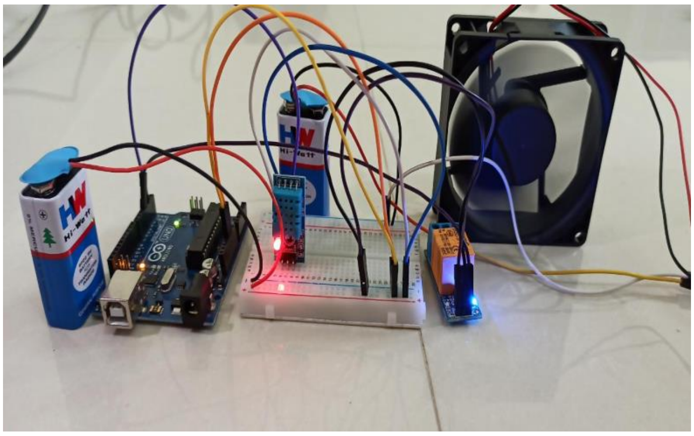

Figure 6. Arduino Setup

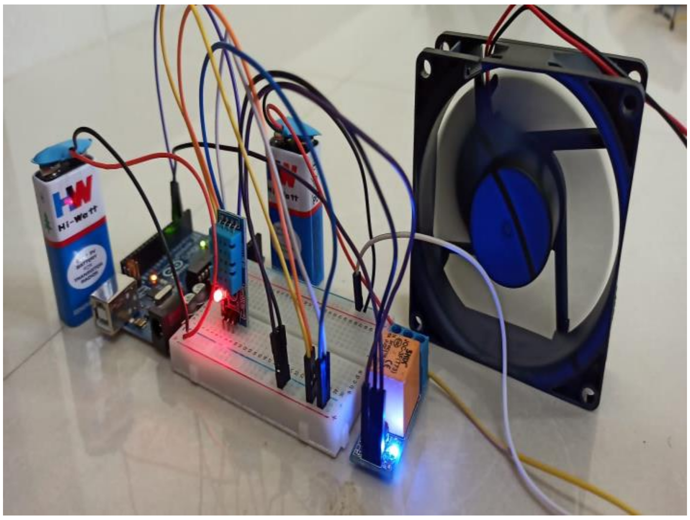

Figure 7. Output Image Side view

## 6. Conclusion And Future Work

In this particular paper, a generic solution for food products is given. In the future, different temperature and humidity settings for different food products can be found out by sensory based monitoring of food products for various conditions. For instance, the best quality in baked goods is achieved by varying humidity at different stages of the baking process. The fermentation of dough-based products at high humidity levels disrupts skin formation. Apart from that, the activation of yeast dough is accentuated by high humidity levels. Fruits and vegetables, owing to their natural moisture content, their cold temperature storage demands humidity levels that are controlled. When fruit and vegetables lose their moisture content, the outcome is deterioration of freshness. Humidification of air in the food industries are mandatory for maintaining the freshness of the products, optimal conditional operation of the production process and increased shelf life. IoT based real time monitoring of temperature and humidity of food products can enable hunger alleviation in underdeveloped countries.

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