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Department of Electronics and Communication Engineering

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Embedded and IoT

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PREFACE

Embedded system is basically the study of how to setup a device that is hardware or software or both that is embedded in a larger system and is mostly a real time system. An embedded system usually consists of a microcontroller programmed to do a specific job.

Internet of things is how these devices communicate with each other directly and indirectly to serve a specific purpose. Directly is when two devices or more talk peer to peer. And decide actions based on what the other device says. Indirect is when all of these devices are connected to a single node and the node receives and transmits signals to the devices and intercommunicate is thus established.

The “Internet” side of IoT is about processing the huge amount of data that can be collected by devices and extract the useful bit of information that can improve the way we use many services and devices today. The applications of embedded systems have increased drastically over the past years. Multi-core technologies are being appreciated and are now in great demand across various industry verticals.

APPLICATION ARTIFICIAL INTELLIGENCE

Shalani – III Year

Artificial Intelligence (AI) is a science and a set of computational technologies that are inspired by—but typically operate quite differently from—the ways people use their nervous systems and bodies to sense, learn, reason, and take action. While the rate of progress in AI has been patchy and unpredictable, there have been significant advances since the field's inception sixty years ago. Once a mostly academic area of study, twenty-first century AI enables a constellation of mainstream technologies that are having a substantial impact on everyday lives. Computer vision and AI planning, for example, drive the video games that are now a bigger entertainment industry than Hollywood. Deep learning, a form of machine learning based on layered representations of variables referred to as neural networks, has made speech-understanding practical on our phones and in our kitchens, and its algorithms can be applied widely to an array of applications that rely on pattern recognition. Natural Language Processing (NLP) and knowledge representation and reasoning have enabled a machine to beat the Jeopardy champion and are bringing new power to Web searches. While impressive, these technologies are highly tailored to particular tasks. Each application typically requires years of specialized research and careful, unique construction. In similarly targeted applications, substantial increases in the future uses of AI technologies, including more self-driving cars, healthcare diagnostics and targeted treatments, and physical assistance for elder care can be expected. AI and robotics will also be applied across the globe in industries struggling to attract younger workers, such as agriculture, food processing, fulfillment centers, and factories. They will facilitate delivery of online purchases through flying drones, self-driving trucks, or robots that can get up the stairs to the front door. This report is the first in a series to be issued at regular intervals as a part of the One Hundred Year Study on Artificial Intelligence (AI100). Starting from a charge given by the AI100 Standing Committee to consider the likely influences of AI in a typical North American city by the year 2030, the 2015 Study Panel, comprising experts in AI and other relevant areas focused their attention on eight domains they considered most salient: transportation; service robots; healthcare; education; low-resource communities; public safety and security; employment and workplace; and entertainment. In each of these domains, the report both reflects on progress in the past fifteen years and anticipates developments in the coming fifteen years. Though drawing from a common source of research, each domain reflects different AI influences and challenges, such as the difficulty of creating safe and reliable hardware (transportation and service robots), the difficulty of smoothly interacting with human experts (healthcare and education), the challenge of gaining public trust (low-resource communities and public safety and security), the challenge of overcoming fears of marginalizing humans (employment and workplace), and the social and societal risk of diminishing interpersonal interactions (entertainment). The report begins with a reflection on what constitutes Artificial Intelligence, and concludes with recommendations concerning AI-related policy. These recommendations include accruing technical expertise about AI in government and devoting more resources—and removing impediments—to research on the fairness, security, privacy, and societal impacts of AI systems. Contrary to the more fantastic predictions for AI in the popular press, the Study Panel found no cause for concern that AI is an imminent threat to humankind. No machines with self-sustaining long-term goals and intent have been developed, nor are they likely to be developed in the near future. Instead, increasingly useful applications of AI, with potentially profound positive impacts on our society and economy are likely to emerge between now and 2030, the period this report considers. At the same time, many of these developments will spur disruptions in Substantial increases in the future uses of AI applications, including more self-driving cars, healthcare diagnostics and targeted treatment, and physical assistance for elder care can be expected. 5 how human labor is augmented or replaced by AI, creating new challenges for the economy and society more broadly. Application design and policy decisions made in the near term are likely to have long-lasting influences on the nature and directions of such developments, making it important for AI researchers, developers, social scientists, and policymakers to balance the imperative to innovate with mechanisms to ensure that AI's economic and social benefits are broadly shared across society.

Healthcare

There has been an immense forward leap in collecting useful data from personal monitoring devices and mobile apps, from electronic health records (EHR) in clinical settings and, to a lesser extent, from surgical robots designed to assist with medical procedures and service robots supporting hospital operations. AI-based applications could improve health outcomes and the quality of life for millions of people in the coming years. Though clinical applications have been slow to move from the computer science lab to the real-world, there are hopeful signs that the pace of innovation will improve. Advances in healthcare can be promoted via the development of incentives and mechanisms for sharing data and for removing overbearing policy, regulatory, and commercial obstacles. For many applications, AI systems will have to work closely with care providers and patients to gain their trust. Advances in how intelligent machines interact naturally with caregivers, patients, and patients' families are crucial.

Education

Enabling more fluid interactions between people and promising AI technologies also remains a critical challenge in Education, which has seen considerable progress in the same period. Though quality education will always require active engagement by human teachers, AI promises to enhance education at all levels, especially by providing personalization at scale. Interactive machine tutors are now being matched to students for teaching science, math, language, and other disciplines. Natural Language Processing, machine learning, and crowdsourcing have boosted online learning and enabled teachers in higher education to multiply the size of their classrooms while addressing individual students' learning needs and styles. Over the next fifteen years in a typical North American city, the use of these technologies in the classroom and in the home is likely to expand significantly, provided they can be meaningfully integrated with face-to-face learning. Beyond education, many opportunities exist for AI methods to assist.

Teaching Robots

Today, more sophisticated and versatile kits for use in K-12 schools are available from a number of companies that create robots with new sensing technologies programmable in a variety of languages. Ozobot is a robot that teaches children to code and reason deductively while configuring it to dance or play based on color-coded patterns.75 Cubelets help teach children logical thinking through assembling robot blocks to think, act, or sense, depending upon the function of the different blocks.76 Wonder Workshop's Dash and Dot span a range of programming capabilities. Children eight years old and older can create simple actions using a visual programming language, Blockly, or build iOS and Android applications using C or Java.77 PLEO rb is a robot pet that helps children learn biology by teaching the robot to react to different aspects of the environment.78 However, while fun and engaging for some, in order for such kits to become widespread, there will need to be compelling evidence that they improve students' academic performance.

AI research

Machine learning has been propelled dramatically forward by impressive empirical successes of artificial neural networks, which can now be trained with huge data sets and large-scale computing. This approach has been come to be known as "deep learning." The leap in the performance of information processing algorithms has been accompanied by significant progress in hardware technology for basic operations such as sensing, perception, and object recognition. New platforms and Longer term, AI may be thought of as a radically different mechanism for wealth creation in which everyone should be entitled to a portion of the world's AI-produced treasures. 9 markets for data-driven products, and the economic incentives to find new products and markets have also stimulated research advances. Now, as it becomes a central force in society, the field of AI is shifting toward building intelligent systems that can collaborate effectively with people, and that are more generally human-aware, including creative ways to develop interactive and scalable ways for people to teach robots.

These trends drive the currently “hot” areas of AI research into both fundamental methods and application areas:

Large-scale machine learning concerns the design of learning algorithms, as well as scaling existing algorithms, to work with extremely large data sets.

Deep learning, a class of learning procedures, has facilitated object recognition in images, video labeling, and activity recognition, and is making significant inroads into other areas of perception, such as audio, speech, and natural language processing.

Reinforcement learning is a framework that shifts the focus of machine learning from pattern recognition to experience-driven sequential decision-making. It promises to carry AI applications forward toward taking actions in the real world. While largely confined to academia over the past several decades, it is now seeing some practical, real-world successes.

Robotics is currently concerned with how to train a robot to interact with the world around it in generalizable and predictable ways, how to facilitate manipulation of objects in interactive environments, and how to interact with people. Advances in robotics will rely on commensurate advances to improve the reliability and generality of computer vision and other forms of machine perception.

Computer vision is currently the most prominent form of machine perception. It has been the sub-area of AI most transformed by the rise of deep learning. For the first time, computers are able to perform some vision tasks better than people. Much current research is focused on automatic image and video captioning.

Natural Language Processing, often coupled with automatic speech recognition, is quickly becoming a commodity for widely spoken languages with large data sets. Research is now shifting to develop refined and capable systems that are able to interact with people through dialog, not just react to stylized requests. Great strides have also been made in machine translation among different languages, with more real-time person-to-person exchanges on the near horizon.

Collaborative systems research investigates models and algorithms to help develop autonomous systems that can work collaboratively with other systems and with humans.

Crowdsourcing and human computation research investigates methods to augment computer systems by making automated calls to human expertise to solve problems that computers alone cannot solve well.

Algorithmic game theory and computational social choice draw attention to the economic and social computing dimensions of AI, such as how systems can handle potentially misaligned incentives, including self-interested human participants or firms and the automated AI-based agents representing them.

Internet of Things (IoT) research is devoted to the idea that a wide array of devices, including appliances, vehicles, buildings, and cameras, can be interconnected to collect and share their abundant sensory information to use for intelligent purposes.

Neuromorphic computing is a set of technologies that seek to mimic biological neural networks to improve the hardware efficiency and robustness of computing systems, often replacing an older emphasis on separate modules for input/ output, instruction-processing, and memory.

Challenges and opportunities

One might have expected more and more sophisticated use of AI technologies in schools, colleges, and universities by now. Much of its absence can be explained by the lack of financial resources of these institutions as well as the lack of data establishing the technologies' effectiveness. These problems are being addressed, albeit slowly, by private foundations and by numerous programs to train primarily secondary school teachers in summer programs. As in other areas of AI, excessive hype and promises about the capabilities of MOOCs have meant that expectations frequently exceed the reality. The experiences of certain institutions, such as San Jose State University's experiment with Udacity,91 have led to more sober assessment of the potential of the new educational technologies.

The resounding success of the data-driven paradigm has displaced the traditional paradigms of AI. Procedures such as theorem proving and logic-based knowledge representation and reasoning are receiving reduced attention, in part because of the ongoing challenge of connecting with real-world groundings. Planning, which was a mainstay of AI research in the seventies and eighties, has also received less attention of late due in part to its strong reliance on modeling assumptions that are hard to satisfy in realistic applications. Model-based approaches—such as physics-based approaches to vision and traditional control and mapping in robotics—have by and large given way to data-driven approaches that close the loop with sensing the results of actions in the task at hand. Bayesian reasoning and graphical models, which were very popular even quite recently, also appear to be going out of favor, having been drowned by the deluge of data and the remarkable success of deep learning.

Over the next fifteen years, the Study Panel expects an increasing focus on developing systems that are human-aware, meaning that they specifically model, and are specifically designed for, the characteristics of the people with whom they are meant to interact. There is a lot of interest in trying to find new, creative ways to develop interactive and scalable ways to teach robots. Also, IoT-type systems— devices and the cloud—are becoming increasingly popular, as is thinking about social and economic dimensions of AI. In the coming years, new perception/object recognition capabilities and robotic platforms that are human-safe will grow, as will data-driven products and their markets.

AN INTELLIGENT DOOR SYSTEM USING RASPBERRY PI

Ashwanth – III Year

Qn intelligent door system using Internet of Things, which notifies intrusion by sending out email notification to the owner. It logs all the intrusion data into google spreadsheet of owner's google drive account. ADXL345 accelerometer detects the change in motion of the door and raspberry pi to read sensor intrusion data and to communicate to the Amazon Web Services Internet of Things(AWS IoT) console. Based on the messages from the AWS IoT console, AWS Simple Notification Service(SNS) will send out email notification to the concerned owner based on the AWS IoT console message. Simultaneously all the intrusion logs are stored into google spreadsheet by OAuth2.0 protocol to access related google Application program inter face (APIs). Obtaining the accelerometer sensor data is done by using python programming language and interface the obtained data on IoT. By successfully performing this system, it can be used as a prototype in strengthening door security in many applications such as bank burglary, home invasions, Ram-raiding, office door breaching and lock picking. The proposed system provides a break through by utilizing the sensor activity on various applications as it is represented using Amazon Web Services IoT which is an emerging area of research.

Engineers with business methodologies are the greatest support to our society. The advancements in technologies drive their thoughts and speculates to achieve various goals in fields of science. Arduino has been used as a platform to work for a long time. But with the dispatch of Raspberry pi, a credit card size low-price affordable computer, Arduino is no longer used in application platform. Raspberry pi platform is being used widely from the past few years as it provides easy use support and documentation. It is readily available to all the end users. From simple educational to smart application projects, Raspberry Pi has proved its significance in the development of applications spreading out in various fields. Raspberry Pi equipped with a internet access (Wi-Fi USB dongle or Ethernet cable) is used as a network device. The ADXL345 is a smart 3-axis accelerometer sensor which is small, thin with high resolution (13=bit) measurement at up to ±16g and runs on ultra low power. Digital output data is available as 16-bit 2's complement and is accessible through either a SPI (3- or 4-wire) or I2c digital interface. It is preferred mostly for all mobile device applications. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Its high resolution (3.9 mg/LSB) enables measurement of inclination changes less than 1.0°.

Raspberry pi is interfaced with sensors to obtain related sensor reading data. This device has been widely used in many fields. Reading the data of the sensor's on arduino was studied from arduino based embedded system paper. Intelligent Transport System using visual motion sensor was proposed by M. Soga and K.Yamada. Andrew Burkett has proposed an excellent system to interface raspberry Pi to a Six-Axis Gyro sensor based on a MPU6050 chip. It also show commands to interface the sensor and install the smbus module with some simple Python code to read the data it offers. G.Z. jinn & X.Y.Chen had research on this key technology and its applications for Internet of Things. Feng X and Lawrence proposed a very basic system for communicating to internet of things and should be extended to allow other sensors to be configured with different parameter levels. In my application, I have embedded intrusion data into a web server. It allows to make a simple http re quest to the Raspberry Pi and get a reading from the sensor and log data into spread sheet.

System design

Hardware System Design

Raspberry Pi board

Raspberry Pi board is a miniaturized fascinated computer having ample processing speed and size not bigger than credit card. Incredible things can be done by using it. Firstly, To work with raspberry pi, we need a list of things to get desired operation and functioning. The Model B+ is the most popular updated version of the Pi, with an enhanced functionality. But it uses bit more power to feed the processor. The Model B has received a stealthy update after it was released by adding some more RAM. But the Raspberry Pi Foundation has released third version of the Model B called the B+. Difference exists in the arrangement of components on the pi board. Sd card is sized to Micro sd along with the removal of the video outport. Four usb ports are now available compared to two on model B. All the input and output pins are placed along the sides of the pi to make workspace for project. 40 GPIO pins are now accessible while preserving the same layout as previous version. Same pin configuration is reserved which comes in handy in implementing old projects which were on old pi models. Nearest form factor is achieved as all the connections are along broad edge. Two more clock signals are available along with three extra serial peripheral.

Accelerometer sensor- ADXL 345

The ADXL345 is an accelerometer sensor with high resolution (13=bit) measurement at up to ±16g. It is programmed to raspberry pi using I2c interface or SPI interfaceSensor can be interfaced to raspberry pi by using two methods. One by using simple fritzing connection of pins and the other by sunfounder kit.

Additional Hardware utilized Compatible to Raspberry Pi

For the project use of Raspberry Pi is not enough. For input and connectivity some other devices are required.

1. Wifi Adapter
2. SD card
3. Monitor
4. HDMI to VGA converter
5. Mouse and Keyboard

Software System Design

Raspbian OS

Raspbian Jessie version is used in this project. It is based on Debian linux and different versions of os are named from toy story film characters. This Os is fully revised for the raspberry Pi's hardware. Modifications were made to enhance system processes performance. It runs LXDE (Lightweight X11 Desktop Environment) as the desktop environment. Upgrading to raspbian jessie from rasbian wheezy will add a considerable amount of changes and improvements to desktop user interface. Pi python programming:

a. GPIO library: "sudo apt-get install python-rpi. gpio"
b. I2C library : "sudo apt-get install i2c-tools"
c. Installation of python-smbus module
d. Connecting ADXL345 sensor: After connecting accelerometer, run i2cdetect command to check the connection.

AWS IoT

AWS IoT permits guarded, bi-directional communication between IoT devices (such as sensors, actuators, embedded devices, or smart appliances) and the AWS cloud over MQTT. This platform facilitate required connections between people and things. Real time data collection, analysis and processing of the position information, data visualization transmission of messages using SNS module are the main features of AWS IoT. It helps in easy transfer data from embedded devices such as Arduino, Raspberry Pi.

Raspberry Pi-3 Model B Raspberry pi

It is the credit size low cost as well as low power computing device. Motivation for building such a tiny computer with HDMI out is to build the skills in the young generation in somewhat more interesting way. Some students (6 in numbers) of University of Cambridge, United Kingdom analyzed the data of student enrollment of past few years in two parameter, one was number of student applying in computer science technology and the second parameter was computer skills. They evaluated the data and further concluded that number of applicants (students) for Computer Science are decreasing every year due to lack of skills in Computer Technology. By keeping this problem for the background of motivation, theses six students decided to build a small computer device which can do the physical computation. Physical computation means to make the personal computer capable for being interact with the real world hardware such as sensors, web servers, robots, locks and much more. For this physical computation, Raspberry has provided the GPIO (General Purpose Input Output) pins. These pins are like those standard input output pins which were dedicated in your personal computer for standard devices like Mouse and Keyboard etc. This GPIO module has made Raspberry different from other computer devices. This inspiration of raspberry Pi is more than enough to drive the Internet of Things (IoT) concept into the reality. Raspberry is a microprocessor; therefore it requires an operating system to deal with it. Raspberry is the open source hardware and it has the compatibility with most well-known operating systems like Windows 10, Linux, UNIX and many others. But for the sake of convenience, raspberry has launched two its own operating system which are Linux based i.e. Raspbian and NOOBS.

Unlike Raspberry, Arduino does not require any operating system for performing its operation. It does not require any interpreter or firmware. Arduino is coded in Arduino IDE software which can run on different Operating Systems like Mac, Windows and Linux. The code is written in Arduino IDE which is then compiled in machine or byte code, which further burned for hardware that is attached with Arduino board.

Detecting intrusion of a door and sending the sensor information utilizing AWS IoT and Raspberry Pi explained. The objective is to design and implement the system to notify the owner when there is an intrusion and logging all the data into google spread sheet for further inspection. In this system, ADXL 345 acclerometer sensor is used to sense any change in the motion of the door and raspberry pi to communicate to the AWS Iot console. When there is an intrusion at the door, IoT console invokes SNS module to send notification to the owner. Intrusion data is logged simultaneously into the service account google drive in form of spread sheet. The proposed work is done in two stages, which are in hardware implementation and software implementation as we discussed earlier. Firstly, we have to register raspberry pi device on AWS IoT and download certificate so that to enable communication with the IoT cloud. Certificate should be placed in the parent directory of the program using python. It contains secured credentials to connect to IoT console. Raspberry Pi should have a resource to be created in cloud. Device thing is to be created next by the same name of raspberry pi. No need of additional attributes for creating this thing. Using python programming, certificates can be generated. Alternatively selecting sdk as Node Js, unique certificates for pi device can be created.

Winscp program is used to transfer necessary certificates and libraries to the pi memory. Communication is done by using ip address of the raspberry pi. This program provides bi-directional transfer of files. In addition to IoT certificate, AWS requires license from Symantec. It is acquired by python programming and results a public private certification authority key file. For raspberry pi to create or edit a spread sheet, it should get a authentication from Google drive API scope. OAuth 2.0 is used to request access to drive a pi. A service account is created under a main google mail and it will be given access to spreadsheet. In order to access APIs, related credentials are required like an API key, Service account or OAuth 2.0 client id. In this system, a service account is created having login information such as client id and private key. Required oauth2client libraries are installed for python. Door is equipped with accelerometer sensor so that X-axis is always facing top. When door is closed, readings of the sensor are negative in Z plane. If there is an intrusion, Readings of Z axis become zero or positive. If intrusion happens, it will publish a string "Intrusion detected" to the SNS console and email is sent instantaneously and spread sheet is updated.

Trade-Off between Raspberry Pi-3 & Arduino Uno

One major confusion that could arise in reader‟s mind, which board must we purchase for performing our electronics experiments? The answer of this question depends upon to which type of project you are dealing with. If you are doing the electronics project that do not require much processing power like controlling motors, LEDs, robotics and sensors etc., then Arduino Uno will best fit to your requirements. But if the project in which you are interested requires much physical computations and Graphics like Web servers, Games, Media Centre, industrial/ Home automation, wireless access point, environmental sensing and monitoring, Robotics, Security monitoring and cloud servers etc., you should switch towards Raspberry Pi 3.

It is portable and easily upgradable. Adding with different types of sensors along with the proposed system, we can make many smart applications like home automation, Eagle eye monitoring, and Bank door security. With the addition of smart things compatible lock system, we can lock or unlock door from anywhere using smart phone. Interfacing with servo motor can be useful further to trigger the door to automatically unlock or lock as someone approaches. Smart things compatible alarm system is future improvement of proposed system which notifies intrusion by a loud alarm. This project is a prototype for various security applications based on raspberry pi and internet of things.

SENSORS USED IN IOT DEVICES AND THEIR APPLICATIONS

Sharmilaa – IV Year

Sensors are the troops of the "internet of things," the on-the-ground pieces of hardware doing the critical work of monitoring processes, taking measurements and collecting data. They are often one of the first things people think of when picturing IoT.

The decreasing price of these tiny devices is helping keep IoT deployment costs low and enabling a myriad of use cases. But not every sensor is made the same and every IoT installation requires a specific type of sensor. We will take a look at several different sensor flavors and their corresponding use cases.

Temperature Sensors

These sensors allow an IoT device to know the temperature of objects and function according to it. Once installed, these sensors use different methods to determine the heat or temperature of the given object/surface. The sensors don't always have to be in physical contact, some can detect temperature from Laser and IR. ADT7320 is a typical example.

One of the most widely used sensor category which has application in energy management, cars, manufacturing shop floor and environment.

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming

The TMP36 is a low voltage, precision centigrade temperature sensor. It provides a voltage output that is linearly proportional to the Celsius temperature. It also doesn't require any external calibration to provide typical accuracies of ±1°C at +25°C and ±2°C over the −40°C to +125°C temperature range.

Temperature sensors are widely used in engineering and scientific applications, especially measurement systems. They are found within roadways in cold weather climates in order to help determine if icing conditions exist. Indoors, temperature sensors are used in several climate control systems including refrigerators, freezers, air conditioners and water heaters.

These devices can be used in nearly every IoT environment, from the factory floor to agricultural fields. In manufacturing, these sensors can continually measure the temperature of a machine to ensure it stays within a secure threshold. On the farm, they are used to track the temperature of soil, water and plants to maximize output.

Applications: Thermostats etc.

Humidity/Moisture Sensors

In many cases, knowing humidity of environment alongside Temperature is necessary for better operations and this is when sensors like HTU21D and NPA-700 come into play.

A humidity sensor (or hygrometer) senses, measures and reports the relative humidity in the air. It therefore measures both moisture and air temperature. Relative humidity is the ratio of actual moisture in the air to the highest amount of moisture that can be held at that air temperature. The warmer the air temperature is, the more moisture it can hold. There are many different kinds of humidity / dew sensors categorized by accuracy, operating temperature range, humidity range, supply voltage, packaging type and supply current. They find application in environment monitoring sector, supply chain, perishable food, agriculture/farming, health monitoring and also HVAC monitoring.

Applications: Humidity sensors are mostly used in thermostats and other weather related IoT Devices.

They can also be found in offices, cars, humidors, museums, industrial spaces and greenhouses and can be used in meteorology stations to report and predict weather. Dew sensors are used in the coating industry because the application of paint may be extremely sensitive to dew point

Accelerometers, gyroscopic sensors Motion/Proximity

Accelerometers can be used to detect acceleration, vibrations or tilt of any object. These type of sensors can be used to measure vehicle acceleration, vibration in vehicles, process control systems, machines, buildings and safety installations.

Gyroscopes are used to measure the angular velocity of an object. Some sensors such as ICM-20628 have the ability to detect and measure both, acceleration and angular velocity.

Applications: Accelerometers are used in pedometers, antitheft devices and levelling. Gyroscopes are used mostly in 3D mouse.

Motion (PIR) sensors are typically used in safety and security monitoring, detecting an intrusion, burglar alarm and kitchen garden protection. **Gyro** sensors are angular velocity sensing, angle sensing and control mechanisms to sense the vibrations produced by external factors.

Proximity Sensor

Proximity sensors have a wide range of applications including parking assistance, conveyor systems, vibration measurements, roller coasters, anti-aircraft warfare, mobile phones and touch screens on mobile devices.

Commonly used in security, safety or efficiency applications, Proximity sensors are used to detect motion. These sensors utilize electromagnetic radiation or radar to function and they can sense UV Index, 2D or 3D gesture and even heart rate. Si114x and Si1102 are typical examples of Proximity sensors used in IoT.

Applications: These sensors are mostly used in retail industry, parking and museums etc. for safety and security.

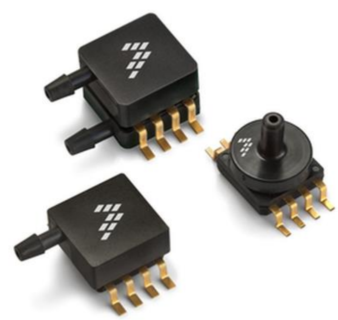
These sensors detect motion and are frequently used in a retail setting. A retailer can use a customer's proximity to a product to send deals and coupons directly to their smartphone. Proximity sensors can also be used to monitor the availability of parking spaces in large venues like airports, malls and stadiums.

Pressure Sensors

These sensors are used to detect pressure of a liquid, gas etc. These sensors work by converting physical power into electronic signals and then sending it into the processors of the device. Pressure gauges are among the most used pressure sensors in the IoT Industry and Barometers are used for accurate weather forecasting.

Applications: Pressure sensors are used in touch screen devices, weather monitoring devices and in automotive industry.

Pressure sensors are very handy in different applications ranging from aircraft, automobiles, to weather instrumentation and any other machinery that has pressure functionality implemented. Other applications for pressure sensors include measuring flow and to calculate the level of a fluid or a loss of pressure due to a system leak. Example on the right - MPX5010/MPXV5010G/MP3V5010 series of piezoresistive transducers by NXP.



Agriculture is the biggest user (and waster) of water in the world. Farmers use 70% of the world's freshwater, but 60% of it is wasted due to leaky irrigation systems, inefficient applications methods and the cultivation of thirsty crops, according to the World Wildlife Fund. Pressure sensors can be used to determine the flow of water through pipes and notify the correct authority when something needs to be fixed. They are also used in smart vehicles and aircraft to determine force and altitude, respectively.

Position Sensor

Measurement applications for **linear position sensors** include coordinate-measuring machines, gear measurement tension testers, laser scanners and callipers, pick-and-place PCB assembly equipment, robotics, machine tools, wire bonders, printers and digital presses.

Angular position sensors can be found in a wide array of automotive applications including steering wheel, pedal, motor-shaft, throttle, torque, power seat and power mirror position sensing. They can also be used in industrial applications such as valve position sensing, in flow meters and in robotics.

Optical Sensors

Optical sensors have been a great use in digital cameras for years. Optical Sensors can emit, receive and convert the light energy into digital signals. These sensors work by detecting electromagnetic energy and then sending the results to processing units. As digital cameras are one of the most important physical devices in IoT, Optical sensors are sure to have continued applications in the future.

Applications: Among other places, Optical Sensors are used in mining operations, oil refineries and chemical plants.

Light

A Light Sensor is something that a robot can use to detect the current ambient light level - i.e. how bright/dark it is. There are a range of different types of light sensors, including 'Photoresistors', 'Photodiodes', and 'Phototransistors'.

Light sensors have several uses in scientific applications. A light sensor may be part of a safety or security device like a garage door opener or a burglary alarm. Several modern electronics, including TV's, computers and wireless phones use ambient light sensors in order to automatically control the brightness of a screen in situations where light intensity is high or low.

Magnetic

Magnetic field sensors, or "magnetometers", can be categorized into four general types depending on the magnitude of the measured field. If the targeted B-field is larger than the earth magnetic field (maximum value around 60 μT), the sensor does not need to be very sensitive. To measure the earth field larger than the geomagnetic noise(around 0.1 nT), better sensors are required.

For the application of magnetic anomaly detection, sensors at different locations have to be used to cancel the spatial-correlated noise in order to achieve a better spatial resolution. To measure the field below the geomagnetic noise, much more sensitive magnetic field sensors have to be employed. These sensors are mainly used in medical and biomedical applications, such as MRI and molecule tagging.

There are many approaches for magnetic sensing, including Hall effect sensor, magneto-diode, magneto-transistor, AMR magnetometer, GMR magnetometer, magnetic tunnel junction magnetometer, magneto-optical sensor, Lorentz force based MEMS sensor, Electron Tunneling based MEMS sensor, MEMS compass, Nuclear precision magnetic field sensor, optically pumped magnetic field sensor, fluxgate magnetometer, search coil magnetic field sensor and SQUID magnetometer

Water quality sensors

Precision agriculture, water treatment and rainwater quality monitoring – just a few of the more common applications requiring water quality sensors.

Chemical/smoke and gas sensors

These devices can be used for air quality control management in smart buildings and throughout smart cities.

Level sensors

Level sensors detect the level of liquids and other fluids including slurries, granular materials and powders that exhibit an upper surface. Level sensors can be used for smart waste management and recycling purposes. According to

Senix, other applications include measuring tank levels; diesel fuel gauging; liquid assets inventory; high or low level alarms; and irrigation control.

IR sensors

Infrared vision has several applications. It can visualize heat leaks in houses, help doctors monitor blood flow, identify environmental chemicals in the environment and can be integrated with wearable electronics.

Image **sensors**

Image sensors are simple, they can detect and convey the information that constitutes an image and plays a vital role on lot of security and safety applications.

Other Categories

Hall Effect sensors

Hall Effect sensors are often seen in industrial applications and in consumer equipment. They can also be found in various types of sensors such as rotating speed sensors, current sensors, pressure sensors and fluid flow sensors.

Apart from these, depending on the requirements, IoT Devices can have other sensors as well. Some other examples are touch sensors and sound sensors etc.

Endless sensing capabilities

This is a look at a few of the most common applications of sensors for IoT. Of course, autonomous vehicles are filled with sensor technology, including force/load/torque/strain sensors; motion/velocity/displacement/position sensors; and vibration and shock sensors.

Connectivity Technologies and the Internet of Things

An important consideration when developing on the Intel® IoT Platform is deciding on what communication technology (or multiple technologies) makes sense for your particular application. IoT supports many ways to transfer data, and Bluetooth® LE, or Wi-Fi (to name a few) may not be the right fit for every device. The goal of this article is to make your selection easier by exploring the advantages and practical application examples for each technology

4G / LTE*

Long-Term Evolution* (LTE*) is a high speed standard used in wireless communication that is widely deployed on mobile phones.

- **Strengths:** Fast data transfer, with peak download rates up to 299.6Mbit's. Has a high adoption rate.
- **Limitations:** Not optimized for low power consumption. Is a complex system, with higher costs in implementation and maintenance.
- **Well Suited For:** Larger markets include Smart City, and Industrial Automation. Other uses include automated vehicles, and fleet management.

BACnet*

BACnet* is a communication protocol developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) for use in heating and cooling appliances. The standard operates over other communication standards such as ARCNET, Ethernet, ZigBee* and LonTalk*.

- **Strengths:** Specifically tailored to the needs of heating and cooling devices.
- **Limitations:** Not built for anything out of the heating and cooling space.
- **Well Suited For:** Larger markets include Smart City, Building Management Systems, and Smart Home. Other uses include HVAC, lighting control, access control, and fire detection systems.
- **Example:** The E50H5 BACnet MS/TP DIN Rail Meter is used in Smart Buildings to monitor power, and tracks usage of gas, water, steam, or other energy form.

Bluetooth® LE

Bluetooth® Low Energy is a wireless technology for creating personal area networks. This is an offshoot of Bluetooth® technology designed to run in low power situation.

- **Strengths:** Well suited for small devices with low power resources. A low cost technology that is compatible with a large installed base of devices. The small physical size also is useful for building small devices, such as wearables.
- **Limitations:** Range limited to 100m, and maximum throughput is 2.1 Mbits/s.

- **Well Suited For:** Larger markets include Smart Home, Visual Retail and Buildin Management Systems. In addition, can be found in fleet management and telematics, health care, sports and fitness, and human interface devices.
- **Example:** In this code sample, Bluetooth LE is used with a TI SensorTag CC2650 to monitor the enviornment, such as in a Smart Home.

GPRS*

General Packet Radio Service* (GPRS*) is a mobile communication standard that uses GSM (global system for mobile communications) on 2G and 3G networks. It is different from other mobile technologies in that it's a best-effort service that guarantees a minimum quality of service to the communication.

- **Strengths:** A good candidate for "always on" connections. An older standard that can connect to legacy devices, and networks that have wide been widely adopted.
- **Limitations:** Only supports low speed mobile communications.
- **Well Suited For:** Larger markets include Smart City, Visual Retail and Industrial Automation. In addition it is also used in transportation, and fleet management.
- **Example:** The Grove GPRS Module, V2 is detailed here, and is used to connect a variety of sensors in Visual Retail situations, .

GPS

GPS, or Global Positioning System, is a global navigation network based on a network of satellites. Devices with GPS receivers are able to pinpoint their precise coordinates.

- **Strengths:** Freely available, and implemented on military hardware. Available almost everywhere.
- **Limitations:** A one way communication method that only receives data. Used only for reporting location data.
- **Well Suited For:** Larger markets include Industrial Automation. In addition, can be used in transportation based devices, fleet management, and automated vehicles.
- **Example:** The UBLOX LEA-6H based GPS shield from DFRobot is used to connect to a variatey of sensors in Industrial Automation.

LoRaWAN*

A long range, low power platform. Data is encrypted, and available to regional, national, or global networks. This technology is intended for battery powered devices.

- **Strengths:** Long range communication range of up to 2-5 kilometers in dense urban areas. Low power consumption.
- **Limitations:** Lower data speeds over 3G networks.
- **Well Suited For:** Larger markets include Smart City, and Industrial Automation. Also used in fleet management and wearable devices.
- **Example:** The SX1276 LoRa/FSK Modem is used to connect to a variety of sensors in a Smart City environment.

Modbus

Modbus is a protocol designed to communicate over serial com ports It is a tried and true technology, having being developed in 1979 for working with programmable logic controllers (PLCs). Since then, the technology has been extensively used in industrial applications.

- **Strengths:** Solid, time proven communication method. Compatible with older devices, and may be used to connect to legacy technology already in place. This is also an open protocol, and can be implemented without cost.
- **Limitations:** Restricted to a single, non-wireless transmission method.
- **Well Suited For:** Larger markets include Smart Home, Visual Retail and Building Management Systems.
- **Example:** The T3311 Temperature and Humidity transmitter is being deployed for Smart Building to monitor temperatures in building HVAC automation, warehouse, and for archival storage in museums.

NFC/RFID

Near field communications (NFC) is a subset of RFID technology that allows for wireless communication between very short distances of about 1.6 inches. This is generally used for transferring data from embedded chips in plastic cards, such as credit cards.

- **Strengths:** Chips that contain data need no power. Low cost to implement.
- **Limitations:** Restricted to transferring small amounts of data at close range.
- **Well Suited For:** Larger markets include Smart Home, Visual Retail and Building Management Systems. Additionally, it has been used in card authentication, commerce, and bootstrapping other communications methods.
- **Example:** The Sparkfun RFID Evaluation shield is used to in Visual Retail to read RFID chips.

SigFox*

A low power, wide area network designed to operate on the Industrial, Scientific, and Medical ISM radio band. This is a closed standard

- **Strengths:** Low cost, and low energy. Compatible with Bluetooth, GPS, 2G/3G/4G, and Wi-Fi.
- **Limitations:** Proprietary solution offered by SigFox*.
- **Well Suited For:** Larger markets include Smart City, and Industrial Automation. Also found in fleet management, retail, agriculture, and Health & assisted living, and home automation.

Wi-Fi

Wi-Fi is a wireless standard that most people will be familiar with for establishing local area networks. Wi-Fi networks are standard for both home and office applications.

- Strengths: Widely adopted and ubiquitous. Long range when compared with other technologies. Good data throughput rates.
- Limitations: Power consumption is high, and physically size is large.
- Well Suited For: Larger markets include Smart Home, Visual Retail and Building Management Systems. In general, useful for larger boards and gateways that have access to robust power resources. In addition, found in intelligent vending machines, smart homes, Fleet Management and Telematics.
- Example: Wi-Fi is used to monitor the environment for Smart Home or Buildings in the How to Build an Environment Monitor Solution reference implementation.

Z-Wave*

Z-Wave* is a wireless technology developed for use in home automation. It is designed for reliability, and low latency.

- **Strengths:** Specialized for use in home automation, and can be considered a drop in solution for home IoT devices.
- **Limitations:** About 30 meter range. A low data rate system.
- **Well Suited For:** Larger markets include Smart Home, Visual Retail and Building Management Systems. Additionally, its found in lighting, HVAC, security, and home cinema applications.
- **Examples:** The Trane TZEMT400 Z-Wave Thermostat is used in Smart Home applications to monitor temps, and for remote management.

ZigBee*

ZigBee* is a wireless technology for deploying personal area networks that has been designed to be small, low power, and inexpensive. As a simple system, it's suitable for a wider range of less complex devices, such as light switches.

- **Strengths:** Low latency and power consumption make it ideal for battery powered devices, which can run for years. It's simple topology allows it to be integrated with other simple devices.
- **Limitations:** Range is limited to 10-100 meters and is line of sight. Low data rates.
- **Well Suited For:** Larger markets include Smart Home, Visual Retail and Building Management Systems. In addition, it's found in home entertainment, industrial control, medical data collection, and Smoke/Intruder warnings applications.
- **Example:** The Z311X, Netvox ZB11D* and more are used to build a smart conference room in this Intel case study

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