Real Time Applications of Industrial IOT in Various Fields – A Survey

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ABSTRACT

Industrial Internet of Things (IIoT), a branch of Internet of Thing (IoT) is the application of IoT in manufacturing and other industrial processes to improve their operational efficiency. It uses ubiquitous sensed data and performs advanced cloud based analytics using AI and machine learning algorithms to perform real time actions. IIoT application is found in many areas such as manufacturing industry, mining industry, healthcare industry, oil and gas industry, agriculture and so on. By using IIoT in manufacturing industries, we can resolve the drawbacks in traditional manufacturing by predicting the machine failure earlier and solve it immediately thereby reducing the operational cost, resource wastage and improves the worker's safety. Application of IIoT in healthcare domain is also an important consideration. In this paper, the usages of smart sensors and UAV in various IIoT applications are reviewed. These papers also focus on application of IIoT in various fields like smart factory, food industry, healthcare and power plants.

Index Terms - IIoT, UAV, Ubiquitous sensing, Cloud based analytics

I. INTRODUCTION

The main motive of IIoT is to enhance the operating condition of machine and increase its lifetime thereby optimizing the operational efficiency. Here sensors and actuators are used not only to control critical elements but also to enhance and optimize various functions. (i.e., To monitor health of various machines, To track various operations and emergency system etc.,). The data collected from deployed sensors and actuators can be analyzed using advanced analytical tools and algorithms.

IIoT often used interchangeably as "Industrial Internet" which was coined by General Electronic (GE). According to GE, Industrial Internet can be defined as "the association of the global industrial system with low cost sensing, interconnectivity through internet, high level computing and analytics"[2].

[2]Industrial internet is used in various sectors like commercial aviation, Rail transportation, Power production, Oil and Gas sectors and healthcare. Commercial aviation industries gets benefited by improving asset management and airline operations like effective flight scheduling, minimizing delay and cancellations of flight. In Rail transportation, real time analysis and predictive algorithms will help in reducing maintenance cost and in preventing engine breakdown. In Power sector, by using industrial internet concepts, broken power lines are easily

located without field inspection. In oil and gas sector, it helps in real time monitoring of any leakage and having alert system for safety and optimization. In Healthcare, it helps to know the status of the connected healthcare devices and the patients monitor by them.

II. IIOT APPLICATIONS WITH SMART SENSORS

In IIoT, Smart sensors are utilized to sense multiple parameters like temperature, pressure, light, humidity etc at a single sensor node. It shares this vital data to central control unit and then performs A/D or D/A conversion as per the need. Similarly smart actuators are used to achieve precise flow control and better diagnostics.

Smart sensors have self decision making capability and thus downtime cost in industries gets reduced. Industrial smart sensor makes use of high complex signal processing algorithm and onboard circuitry for readjusting and removing the flaws in its response. It's applications [5][6][7] are discussed below.

Applications of Industrial smart sensors		
Type of Industry	Sensor type	Application
Navigation industry	Track Sensor (GPS)	To spot significant places and tracking real time objects
		To analyse traffic and to predict driver destination
Agriculture Industry	Crop Sensor	To determine crop health and use accurate amount of fertilizers based on that assessment
		To detect the best time to plant crop
HealthCare Industry	BioSensor, Nano sensor, Inplantable sensor	To send alert message to other members when the smart pills are swallowed
		To prevent a patient from falling down and report on patient's movement is notified to other members.
Retail Industry	RFID tracking chip	To track location of shipment with GPS and IoT
		Sensors on shopping products and cart to avoid theft
Gas Industry[4]	Gas sensor	To find leakage of toxic gases with alert notification

Table : Applications of Industrial smart sensors

Thus sensor usage helps in improving several industrial processes. Industrial machine's downtime gets minimized by improving the prediction of failure and prevents it earlier.

Several other sensors are also available for industrial and other applications [3]. Especially temperature sensors are utilized to fabricate medical drugs and heat liquid. Time varying stress and strains in ferromagnetic materials are detected by magnetos tractive sensor which in turn used in inspection of steel pipes and condition monitoring of machinery. By using vacuum sensor, pressure below than atmospheric pressure is measured. It is mainly used in different industrial applications like helium leak, chemical processing and in cathode ray tubes. Car electronics, ships and agricultural machines uses acceleration sensor to detect the magnitude and direction of the acceleration. PIR sensor helps to implement automatic door open/close. Speed sensor measures speed and is mainly utilized in vehicle, engine powered generator and compressor.

III. IIOT IN SMART FACTORY

Smart Factory involves equipment and machinery by which processes are improved through self optimization and automation. By using smart factory, real time data are collected and analyzed effectively thus reduces changeover time and production time. Some applications of smart factory includes the following:

A. Caterpillar – AR App[9]

This app generates end to end view of the factory floor by using Augmented Reality(AR) with IoT. By using this view, machine operators detect the necessity for tool replacement. In case of any tool replacement need, AR app sends notification regarding that.

B. Airbus – Factory of future[8]

It was introduced by a European aircraft manufacturer. Here IoT technologies are applied for production. Using this, data on flights are acquired to improve in-flight experience. Iotenabled devices are used by the factory floor workers by which digital tracking and monitoring is made possible.

Tools and machines are fitted with integrated sensors and smart wearables (Industrial smart glasses) are utilized which results in 3D real-time visualization of production process.

C. Amazon – Robotic Shelves[13]

It uses robotic shelves concept where robots carry and rearrange shelves. It helps for automated product search where robots locate and bring shelves to workers. By this technique, the operating cost was proven to be cut down by 20%.

D. Gehring – Connected Manufacturing[10]

It uses cloud based analytics and is mainly used for making honing machines. Real time data of new machines are notified to customers to confirm requirements before placing order thereby optimizes the overall productivity.

E. Maersk – Intelligent Shipping[11]

It is a container shipping company that tracks the assets and consumption of fuel using sensors. Using IoT strategies, refridgerated containers are preserved. Supply chain is optimized by means of using blockchain technology

F. Magna Steyr[12]
i) Magna Steyr – Smart packaging

It is an automotive manufacturer and it uses IoT for tracking tools and vehicles parts. It supports Bluetooth enabled packaging and tracking components in warehouse.

ii) Magna Steyr – Driverless Transport System

A virtual image(digital factory) of entire factory is constructed which provides real time control and thus anomaly is detected. By following the 3D map of the created digital factory, driverless vehicles move the parts along the assembly line. Driverless vehicles also send the sensed data to cloud where it is analysed and deviations are identified.

G. NorthstarBluescope Steel – IoT for worker safety[14]

This steel factory issued attached wearables to helmet and wristbands of workers, which send health parameter of the workers to supervisor. Based on that parameters, supervisor identify whether the worker is overloaded or not. If the worker is overloaded, supervisors will give break to them. Also by using the sensors in it, radiation and toxic gases are detected

IV. IIOT IN FOOD INDUSTRY

In Food industries humidity, composition and temperature of food products are monitored with the help of sensors. Then sensed data are analyzed which allows easier process control and increases the safety

of food products. The main intent is to reduce the wastage of food products by analyzing the real time information.

Some of the advantages of IoT for improving food industries are given as follows:

A. IoT on the Farm

On the Farm, various sensors are used to monitor weather, maturity of crop[15] and occurance of insects in farm.By using soil moisture sensor, irrigation and fertilization usage are optimized.

B. IoT in the Livestock barns

Health parameters of animals are monitored using sensors and feeding cycles are automated based on the sensed result. It helps for diet control and automated temperature control in hatchery and brooding barns.

C. IoT for the consumers

By the initiative of Grocery Manufacturers Associations (GMA), smart label concept was proposed in which product related information are determined using QR code that is printed on the product.[19] Smart label provides the nutrition value of the product, its ingredient details, usage instructions, third party certifications, exposure to allergens, etc.,Thus it helps the consumers to know the complete details regarding product

D. IoT for safety and Compliance

Using IoT insights, unsafe food products are identified and isolated. It helps to take timely action regarding the issues of food safety and quality. Thus it helps the food manufacturers to increase their confidence on food quality.

Also for empowering the workers, safety glasses and other wearables are provided which in turn increasing the productivity.

Thus IoT helps in improving the farm, livestock barns and assists the consumers using smart labels and safeguard the workers with smart wearables.

Several IoT solutions for food industry are proposed in recent years. The following table illustrates them in detail:

Proposed Solution	About the Solution	Purpose of proposal
Diagenetix - BioRanger[16]	A handheld device connects with android app	To detect the occurance of microbial disease andpathogens in food
Eskesso – The cooking sorcery[17]	Smart cooking device with wifi-connection	Cooking status is easily monitored via smart phone app
Culinary Science Industries – Flavor matrix[18]	Solution that performs machine learning and data analysis	To provide user specific food and beverage pairing to enhance flavor of dishes
Intellicup – Smart cups[21]	IoT enabled cups (integrated NFC chip at the cup base)	Helps for smart beverage vending with reduced waiting time and high profit
SpinnInc: Smart coffee brewing machines[20]	Coffee brewing machine connected with Amazon Echo	Provides auto order feature
FarmShelf : Smart indoor farming[22]	IoT enabled solution for crop growth	Allows climate control depends on growing crops and automatic notification on status of crops

Table :IIoT solutions for Food industry

The above proposed solutions helps a lot in improving food industries using IoT enabled devices and IoT methodologies.

V. IIOT IN HEALTHCARE

Nowadays several researchers focus on monitoring the health of a patient in home [25]. Different sensor based devices are used to measure patient's blood pressure, respiration, pulse rate, heart rate, and weight. Sensors collect these data and sends to medical database via internet or any wireless devices. These data are used to detect if any abnormal situation is there or not. As the sensor devices are monitoring patient's health status continuously, it helps to diagnose any disease in an early stage, which reduces hospitalizing the patient.

Different IIoT based healthcare devices are proposed. They help for remote monitoring of the patient's health condition via smart wearables and smart phones. Smart bed concept is proposed to send notification about patient's activity. Some of the IIoT based applications are as follows:

1.   IIoT Based Blood Pressure Monitor   [24]

By using IIoT device, the patient's blood pressure is accessed in real time and compared with standard blood pressure value.If there is any severe deviation, doctors can prescribe medicines for that.

> Ex: iHealth BP5

2.   IIoT Based Oxygen Saturation Monitor[27]

Oxygen saturation is the ratio of oxyhemoglobin to total haemoglobin. To measure oxygen saturation, pulse oxiometry is used. Here IoT is integrated with pulse oxiometry and for connectivity, Bluetooth is preferred

3.   IIoT Based Glucose Level Monitor[27]

The metabolic disease when glucose level is high causes diabetes. Real time monitoring of glucose level helps meal planning, medication and physical activity. To check the glucose level , glucose sensor devices are used and it notifies the patients and doctors in case of any abnormal situation arises. Ex: Dexcom

4.   IIoT Based ECG Monitor[23]

There is a wireless ECG monitor and ECG sensors can collect the bio signals and are sent to the cloud. It is then analysed by medical staffs in real time. Based on the result of analysis, decisions are taken. Ex: QardioCore

5.   IIoT Based Body Temperature Monitor[23]

By using wearable sensor, human body temperature is continuously monitored. It normally measures skin temperature. Here Wireless Body Area Network is used to connect to the gateway. Ex: Kinsa smart thermometer

6.   IIoT Based Contact Lenses[26]

IIoT based smart contact lens consists of micro camera and sensors. It supports wifi signal connected with smart phone. By using this lens, sugar level can be measured from thetears , if any abnormal situation is found, it can detect various diseases based on that.

7.   IIoT Based Asthma Treatment[27]

Asthma, a lifelong disease which cannot be cured but it can be controlled. To take proper dosage of drugs, inhaler is commonly used. Here we use smart inhaler that can keep track via Global Positioning System. ADAMM intelligent asthma monitoring device , wearable device connected with wifi or Bluetooth which can sense cough rate, heart rate and body temperature and from these values, it predicts pre symptoms of asthma attack.

Thus IIoT has many healthcare applications that can help both patients and doctors. By these applications the older people can live safely.

VI. IIOT IN POWER PLANTS

IoT makes power plants fully automated using smart grids. A grid includes wires, substations, transformers, and switches among other things and when everything is completely automated, it increases efficiency.

If all the systems are automated, then advantages[28] are

- There is no need of labor so salary amount is saved
- No need to monitor devices directly, turbines are monitored remotely.
- It acts based on real time data using sensors and different algorithms thus improves performance of turbines.
- IoT can reduce the energy usage of idle machine, if we can switch them off remotely.

IIoT has several applications in power plant sector[30]. Some of them are:

1. Smart boiler

It is for efficient energy usage. Customers can control it by using the mobile application. Ifany defects are there, it automatically report that.

2. Smart water monitoring

It saves water wastage. It can detect water flow and water volume in a pipe in time period and sends that data to cloud.

3. Smart metering

It reduces the energy loss and operational costs are also reduced by managing the operations remotely. So it is the most significant element of smart grid.

4. Building automation

It is used to remotely monitor the building. Lighting systems, Elevators and other electronic systems are connected and controlledthrough internet.
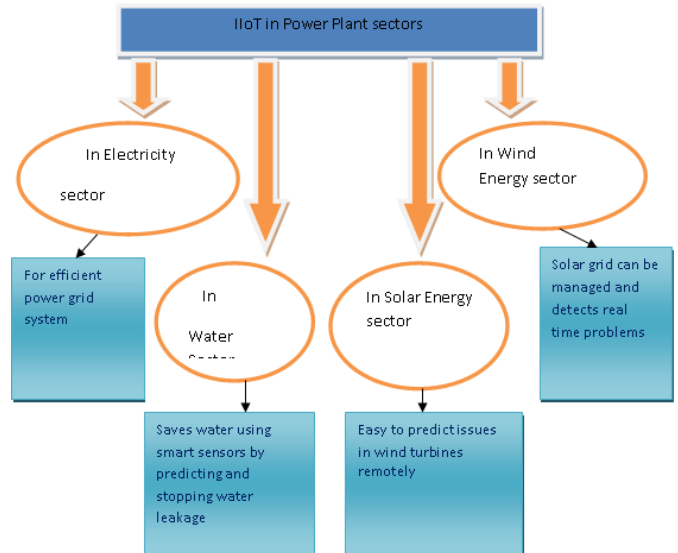
The above figure [29] illustrates the use of IIoT in various power sectors. In Electricity sector, it helps to build efficient power grid system by predicting the failures before it happens. In Water sector, by tracking water pressure and quality it helps to predict water leakage and prevent it earlier.

In wind energy sector, remote wind turbines are monitored and managed effectively. In Solar energy sector, sensors can monitor the performance from the control panel itself and detects the real time problem.

VII. UAV IN IIOT APPLICATIONS

UAV's (Unmanned Aerial Vehicles) gather the assessments using IoT sensors. It is capable to take aerial imagery, thermal imagery, radio frequency imagery and visual imagery of stations and sub stations of the factory. From user to controller, there is an end to end wireless connection. UAV's can directly communicate to an industrial control system (like SCADA).

It has applications in various IoT fields [31]. They are explained below:

A. UAV - Application in Agriculture :

It helps in dispersal of fertilizers and seeds in different areas as per need, thus optimizes the use of them. It monitors the stress factors of crop like drought or over fertilization. It saves time of farmers by assist them in scouting their crops.

B. UAV - Application in Construction sites

It helps in quick survey of job areas in construction sites and in building maps. By UAV's work progress and safety standards in the site are monitored. It reduces the usage of lots of workers and heavy softwares by taking continuous complex readings.

C. UAV - Application in Energy Management

It allows inspection of power poles without climbing in it, thus restricts the people to get closer to dangerous wires. It is also helpful in inspecting wind turbines, solar panels on the farm and dams.

D. UAV - Application in Mining

It helps in exploring the sites and identify any misfire or wall damage. Thus it helps for workers safety puposes. It also helps for optimized blast design by regular surface survey.

E. UAV - Application in Healthcare and delivery

It helps in delivery of vaccines, medicines or snake bite serum to the hospitals and remote areas during emergency situations. Also it helps in transporting blood samples to lab for testing some crucial diseases.

F. UAV - Application in Telecommunication

It helps in tower inspection from any height and angle for maintenance and repair purposes. Also it helps for testing network stability and coverage.

G. UAV - Application in Forestry

It helps to take survey about forest species and helps in measuring density and height of canopy. Also forest fires are tracked using the inbuilt sensors in UAV, thus helps to protect endangered species.

H. UAV - Application in Oil and Gas

It helps in collecting videos and thermal imagery of gas and oil fields and analyse it in industries. By analysing it, oil spill detection, gas leakage and pipeline damage are assessed.

VIII.   CONCLUSION

In this paper, the overview of smart sensors and how it is used in various IIoT applications are discussed. Then implementation of IIoT in smart factory is reviewed with the help of several real time applications. By the application of IIoT in food industry, crop maturity and proper weather condition for growing the crops are determined and wastage of food products is reduced. Also smart label gives the entire product details. On applying IIoT in healthcare domain, patient's health conditions are monitored from a remote place and suggest treatments/medicines based on the analytical result. It also assists old age people to survive safer by using various smart applications. IIoT in power plant industry helps to implement smart electricity grid and smart conservation of solar energy, wind energy and hydropower energy. Application of UAV in various IIoT applications helps for smart farming, smart energy management, remote monitoring, smart telecommunication, safe mining and secure delivery of vaccines/blood samples to remote areas. Thus several real time applications of IIoT are discussed in this paper.

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