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Development of smart Sorting and counting machine for industrial application

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Abstract

This work aims to implement industrial automation landscape by developing efficient systems to connect disparate machines and devices in an industrial environment. By creating an automated, centralized platform accessible via the internet, users can control and monitor all machines in the industry from one place. This work particularly focusses on the conveyor belt application in industry and the implementation of Industry 4.0 in Industries. To achieve this, Cyber-Physical Systems (CPS), Internet of Things (IoT) and Internet of Services technologies are used. These technologies enable efficient operation and monitoring of conveyor systems, ultimately leading to increased productivity, reduced downtime and increased safety. The proposed system provides real-time data for decision-making and optimization, ultimately paving the way for the future of Industry 4.0 in the conveyor belt industry. IoT and Industrial automation is the technology that can be utilized to reduce human interventions and manual overhead in the system to monitor as well as to indicate any errors in the system. Artificial Intelligence could also be used to control and monitor the industry. IoT is not a technology basically it is an ecosystem with Industry Specific Implication. In many Industries monitoring of belt conveyor application is manual with an operator, particularly for sorting application based on color, shape and size of the object. Industry 4.0 leans towards the use of sensor and internet of things to achieve these functions with no errors. This work is an effort made to realize the use of IoT and Industry 4.0 for sorting and counting application in an industrial environment like conveyor belt applications.

Keywords: IoT, Sorting, Conveyor Blet, Industrial Automation, Industry 4.0

1. INTRODUCTION

In manufacturing plants, the material transport plays an important role, especially intra company material transports is vital in many industrial processes such as moving materials from one work station to the other, from one department to the other etc., Similarly the material transfer equipment are important in these processes. Conveyor belt system is one of the commonly used intra-company material transfer equipment. To get more productivity with this material transfer equipment, and to come up with better conveyer belt systems, it is important that continuously carryout research in this equipment. Lot of research are being carried out in recent years in this regard too. Most of the research on conveyor systems concentrates on improving the performance of the conveyor belt systems with different techniques. Automation in material transfer application is also one of the area where lot of research in being carried out recently. Online control of conveyor belt, integration of conveyor with cloud system, controlling conveyor with the use of sensor and feedback systems are very common in this filed. Widely using technique to control the conveyors and most of the material transfer equipment are PLC's (Programmable Logic Controllers)

Modern automatization systems consist of numerous complex operating machines. For them to cooperate in one network, communication protocols were invented. Communication protocols represent a set of rules that allow a communication network to transmit information between the participants. This technique includes not only the information exchange rules but error recovery methods, semantics and synchronization of the communications. Data communication protocols are typically developed into a technical standard for simplicity. The most common data communication protocols that can be encountered in modern PLCs are Ethernet/IP, Profibus, Modbus and ProfNet communication protocols.Even in mining with the continuous improvement of mine automation level, the application of online element rapid analysis technology with high speed, high precision, and strong anti-interference capability in intelligent ore sorting equipment will become an inevitable trend of equipment development in the future [1].
Internet of Things (IoT) is the concept that made the industries smart in terms of its capabilities, the term IoT is introduced in the year 1999, by the members of radio frequency identification development community. With the growth of use of internet, mobile phones, embedded systems, communication cloud computing and data analytics IoT has grown very vast and popular. IoT enables the collection of data from the physical environment of the system with the help of sensors and other devices and store the data in cloud and share it through internet to perform different functions. Integration of Sensors, physical systems, data and share it across the internet to perform specific outcome can be termed as IoT. This technology enables the development and use of different industrial and non-industrial devices to control and monitor to obtain better efficiencies and productivity of the system. In the proposed system the communication between monitor and industrial plant can be achieved using general Pocket Radio Services (GPRS), the distance barrier is eliminated and automation is achieved from any part of the world. Industrial Automation Using Internet of Things (IoT) [2], development of a system which will automatically monitor the industrial applications and generate Alerts/Alarms or take intelligent decisions using concept of IoT [2].

IOT can be achieved by using local networking standards and remotely controlling and monitoring industrial device parameters by using Raspberry Pi and Embedded web server Technology [1]. Raspberry Pi module consists of ARM1 processor and Real Time Operating system whereas embedded web server technology is the combination of embedded device and Internet technology. Using embedded web server along with raspberry pi it is possible to monitor and control industrial devices remotely by using local internet browser.

Development of new technologies that have allowed us to move from the First generation of the Internet into the current transition into the Fourth generation. This generation has been propelled by the concept of the Internet of Things (IoT). IoT based automated temperature and humidity monitoring and control is achieved using a raspberry pi controller running with Linux operating system (OS) coded with C++ program that retrieves the temperature as well as humidity readings and these values are sensed and sent to the internet [3].
Industrial temperature monitoring and control system through ethernet Local Area Network (LAN) is achieved using a Programmable Logic Controller (PLC) based temperature monitoring and control system using virtual instrumentation and LabVIEW. Data acquisition plays an important role in industry in order to ensure the performance and the quality of service [4]. In this system Temperature sensor measures the temperature and corresponding analog signal were produced which is further transferred to the microcontroller. The simulator acquires data from the microcontroller through Ethernet port. The data will be

displayed on the LCD in microcontroller and PC monitor. Automation and control can be done with the help of control circuitry [5].
In the recent years many research work has been done on this area of industrial automation but it also widens the opportunities in improving the techniques and getting superior results in the field.

2. OBJECTIVES

The objective of the current work is to create a network at which feedback from the system could be sensed and prepare an asset in a cloud service to store and to analyze the feedback data. The monitor and drive structures must provide live inspection feedback as well as the transporting rate of the system. The information is further safely transmitted to cloud services for further analytic work to be carried out. The monitor and drive structures have to be able to complete monitoring tasks quickly, reliably and safely when compared to manual inspections.

The following are the main objectives that are brought out through the implementation of the concept of automation in conveyor belt operations:

1. More convenient form of online monitoring that is to say it does not require continuous monitoring by a human operator for any particular process.
2. This approach is to automate the transportation process and drastically decrease human involvement in the process.
3. To implement techniques of IoT and IoS in prototype of conveyor belt system and provide real time continuous monitoring of counting, sorting, tilting and assembly operations taking place on a single conveyor belt.
4. The technologies enable large-scale machine-to-machine and the internet of things communications. The communications open new routes of information exchange between all nodes involved in cyber-physical systems (CPS).
5. By collecting valuable live feedback from CPS systems, the revolution can provide a predictive maintenance schedule that allows owners to perform cost-effective maintenance.

3. PROBLEM WITH EXISTING SYSTEM

Conveyors are the commonly used material transport equipment in industries when the distance between the work stations are less. One of the goals of using conveyors in material handling system is to perform some additional operation during the transfer of materials. The additional operations such as inspection, counting, sorting.
The conveyor belts that are in use at present are overdate and cause a lot of problems including high maintenance and low durability. The present problems with the traditional conveyor belt are discussed below.

3.1. Mis tracking

For the system to produce the results that are intended, conveyor belt tracking the process of aligning and regulating a belt to maintain a certain path is essential. Mis tracking, often known as the belt drifting from one side to the other, can result in unanticipated downtime, belt breakage, product damage, and maintenance troubleshooting problems. When a belt deviates from its intended path, uneven belt wear and even a system breakdown may result.

3.2. Belt Slippage

Too little or too much strain on conveyor belts can have an immediate effect on how well operations run. When the head pulley deteriorates, there is insufficient traction to grip the belt, which results in excessive stretching, noisy squeals, and conveyance slippage. To eliminate buildup, enhance wrap on the drive pulley, or adjust tension requirements, time-consuming maintenance is frequently necessary.

3.3. Seized Rollers

As was already noted, metals generally steel has historically been used to build the majority of conveyor belt rollers. These rollers can eventually become worn out or develop sharp edges when they lock up for a variety of reasons, which causes the belt to track unevenly along the centre line. This can harm the goods or packages being transported in addition to endangering safe working settings. In the event of a total belt failure, due to maintenance the plant may need to shut down for an extended length of time.

3.4. Blockages

A conveyor belt's primary function is to guarantee that material moves efficiently through the system. When this is compromised, the entire process may become jammed, which would halt production. Materials or packages being moved may build up and produce blockages if they collide with sharp edges, experience rigid directional shifts, or travel down a corroded chute surface. A blockage can easily translate to lost production time and non-recoverable production expenses, just like any other conveyor belt issues.

3.5. Material spillage

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4. METHODOLOGY

Belt conveyors are examples of Cyber-Physical Systems (CPS), which integrate various physical processes with communication and computing tools. The primary distinction between CPSs and embedded systems is that CPSs are networks of interconnected devices that converse at a particular level rather than individual units. A typical embedded system consists of a monitoring (control) module that interacts with a number of sensors. However, the layered systems must establish a communication interface that will offer data interchange and data Belt conveyor as a Cyber-physical system in order to comply with the CPS standards. The CPS illustrates the integration of computational and communication tools and structures with specific physical processes.

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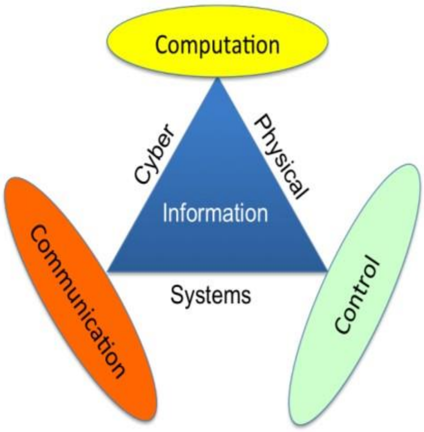

Fig.1. CPS system

The RaspberryPi-3 Model B+, which offers enhanced performance, RAM, and supports good internet connectivity, has been employed in this work for the belt conveyor system. Counting the objects that have been passed on the conveyor system is made easier by using the IR sensor to identify the object. Utilizing a Nema-17 stepper motor, with capacity of 4.8 kg, to power the object tool holder and a sorting arm, conveyor belt system has been developed for this study.

Following the production process, the workpieces of various sizes move along a single conveyor belt and must be further processed in order to be packaged or sent. When the green start button is pressed, the conveyor belt should immediately begin moving forward (identifying the appropriate motor for this application) while carrying the manually placed job pieces toward the photoelectric sensor, which will signal if the object is not the proper height. The PLC program processes the output and then instructs the actuator to either let the thing pass through or toss it out with a piston push. Until the red stop push button is hit to stop the conveyor belt, this procedure should continue in a cycle of repetition. The process used to achieve this useful functionality is described as seen in Fig.2 and Fig.3 below.

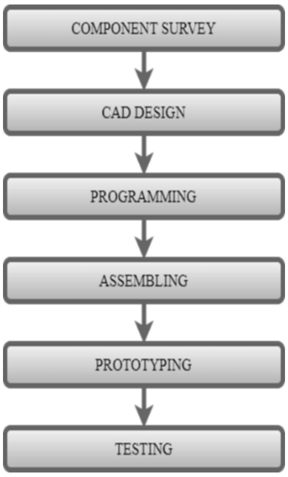

Fig.2. Work Flow

The above figure 2 shows the work flow of the work carried out to complete the system. Initially a CAD design of the conveyor belt system is prepared without any control components. A prototype was built to test the control circuitry with the feedback sensor, following to which the control circuitry was deployed into the system after assembling the components into the systems. Multiple tests were conducted and system was configured to perform the intended operations.

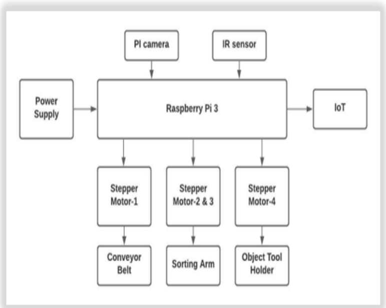

Fig.3. Block Diagram

5. OPERATIONS

5.1. Counting

This is the first operation that takes place on the conveyor belt among the series of the operations. The IR sensor that is directly fitted with the camera helps to count the objects in line on the conveyor. All the objects that are placed on the conveyor belt are directly counted, stored, and meanwhile displayed on the monitor.

5.2. Tilting

For the second sequence of operation on the conveyor belt that is the tilting operation we make use of a static bumper that is fixed to the walls of the conveyor belt. The object whose orientation is to be changed is already in the alignment parallel to the bumper after the sorting operation. Hence thereby when the partial side of the object hits the static bumper the object due to the continuous motion of the conveyor belt tends to change the orientation to the required orientation of the user or the operator. Note that only safe changes of the orientation of the object is achieved thereby ensuring the safety and fragility of the object in line for change in orientation.

5.3. Assembly

This is the last operation that is held on the conveyor and also the most important one. After all the operations are being carried out the object is safely assembled into the object holder that is placed at the major end of the conveyor belt system. The part is assembled into the object holder after being sorted based on the given criteria.
The below figure 4 shows the Flowchart for proposed sequence of operations in which once the object enters the conveyer belt the counter increments and displays as one and the image processing will be done to analyse the shape, and colour of the object. Based on the colour and shape of the object the object will be sorted to diverted to different bins for assembly process.

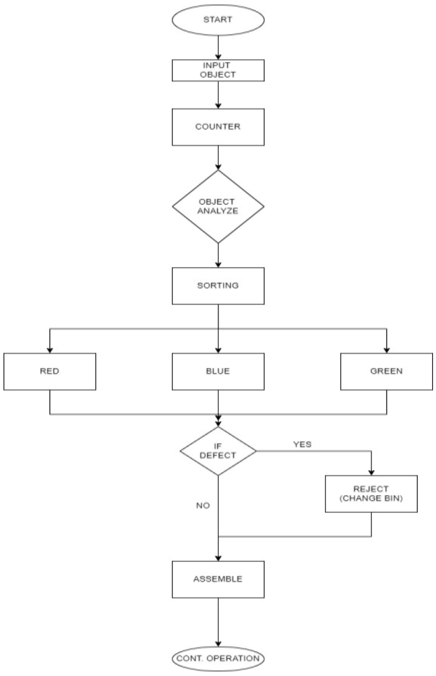

Fig.4. Flow chart for proposed sequence of operations

6. CIRCUIT DIAGRAM

The below diagram figure 5 is the circuit representation of the circuits in connection with the Raspberry pi board. There are four stepper motors that are connected indirectly to the Raspberry pi board through a bread board. The motors require drivers to run based on the input from the board. Also, there is a Raspberry pi camera that is connected to the bottom end pin on the board. An IR sensor that consists of a led emitter and a transistor is connected to read the number of objects that run on the conveyor belt. And a 12V and a 5V power supply is connected to each end of the module that is required to run the motor drives and to run the Raspberry pi board respectively.

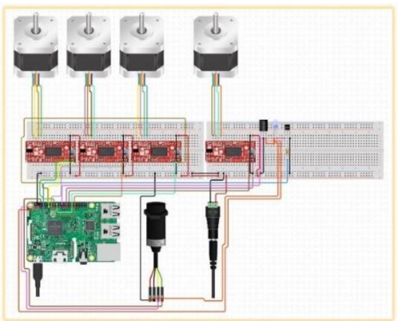

Fig.5. Circuit diagram

For this belt conveyor system, we have decided to use Raspberry Pi 3 Model B+ which has the better performance, RAM and supports good internet connectivity. Using the IR sensor, helps us to detect the object and take the count of the object that has been passed on the conveyor system. Using the Stepper motor Nema 17 – 4.8kg for driving the conveyor belt, sorting arms and the object tool holder.

7. ADVANTAGES AND APPLICATIONS

7.1. Advantages

a. Facilitate easier manual/robot-assisted quality checks of goods in bulk.
b. Reduce dependency on labor and time wastage.
c. Real time continuous monitoring of the product.
d. Multiple uses of single conveyor belt system for different production lines of various prototypes.
e. Reduce the periodic maintenance cost that is otherwise consumed by the typical conveyor belt systems.
f. Interrupts at any stage can be handled easily

7.2. Applications

In reference with the application of conveyor belt in mining industries, the following observations are being made. Conveyor belts are widely used in mineral industry. Underground mine transport, opencast mine transport and processing plants deploy conveyor belts of different kinds to adopt the specific job requirements.
A wider range of material can be handled which pause problems in other transportation means, Belt conveyor can be used for abrasive, wet, dry, sticky or dirty material. The lump size of the transported material is limited by the width of the belt. Belts up to 2500 mm wide are used in mining industry. By the use of many forms of ancillary equipment such as mobile trippers or spreaders bulk material can be distributed and deposited whenever required. Many other functions can be performed with the basic conveying like weighing, sorting, picking, sampling, blending, spraying, cooling, drying etc. Structurally it is one of the lightest forms of conveying machine. It is comparatively cheaper and supporting structures can be used for many otherwise impossible structures such as crossing rivers, streets and valleys.

The belt conveyor can be integrated with other equipment and used for particular purposes such as fire resistance, wear resistance, corrosion resistance, high angle negotiation, etc. The operation and maintenance of a belt conveyor system require the least amount of labor. Belt conveyor can be employed in thin seams in underground mine transportation because it avoids the need for labor works that might otherwise be necessary to increase haulage height. Additionally, belt conveyors can also deliver goods continuously from the bottom of a pit to the surface in mining environment.

8. CONCLUSIONS

A smart conveyor belt system was built by establishing its operating principles, studying the IoT network topologies, and comprehending the system's operating functions for the industries, the system was built from the initial hardware. The objectives of the work were defined based on the information studies, and the entire project was divided into different stages to develop the system.

The integration process for the conveyor belt system helped to present the instruction for each of the devices, that enable creation of the system to be properly linked with each other. The instruction covers the step-by-step procedure of connecting the devices according to the logical network and preparing the asset in the cloud sercice to receive the feedback information from the monitoring system.

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