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A Proposed Modern Manufacturing Technique by using Raspberry Pi based Microcontroller System

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Abstract *- In the current global scenario, automation manufacturing systems are playing a vital role in global upward demand in a market where flexible production systems could be essential to meet the customer demand by the manufacturing industries. It improves the reliability, repeatability, and accuracy of the output at any given point in time; but is successful only if the whole manufacturing system is designed to take care of variations in the environment. Internet of Things (IoT) helps in bringing a closed-loop monitoring system that monitors the output even outside the production environment and applies corrective measures to bring control over the variations. The monitoring system also can alert the operator on the wrong output and guide him to correct the settings and/or discord the wrong output. The system explained in this refers to a complex component output from a CNC machine and how the closed-loop automation system can support an error-free output, as well as store the parameters of the output in a cloud for tracking. This concept can be applied to any machine/component/production process with a well-defined input-output matrix.*

Keywords: *Automation, IoT, Closed Loop System, Medium Scale Industries, Production Process*

I. INTRODUCTION

Recently, automation in the industry has become more viable with numerous advantages. Also, the automation system drastically reduces the environmental effects and increasing the green manufacturing ratio. Apart from that, Industry 4.0 is growing based on ‘intelligent production which mainly focuses on new information technology by recent techniques, independent manufactured goods with decision-making processes [1-4]. The purpose of automation is to replace manual control, planning, and problem-solving by using smart devices and computers. Information techniques related to programmed assignments with appropriate programming and fractional programmed assignments by manual with personal computers develop, manage, and also offer the necessary information.

The usage of this automated technology mainly focuses on factory processing, machinery, communication networks, automatic vehicle controls, aircraft, marines, and so on in which few processes are completely automated. The tremendous advantage of automation is improved quality, precision, accuracy and also saves labor, energy, and materials [5, 6]. A new prevalence is being realized with the latest developed network technologies and Wireless Sensor Networks (WSN) [7, 8]. There has been huge use of networks and has become an integral part of everyday life which enables networking by modifications on the internetworking technologies. Internet technologies and WSN are all about the Internet of Things (IoT) that brings the contact between machine to machine and person-to-computer communications [9]. After the revolution of mobile usage, the IoT is a recent revolutionary technology of our life in which everyday objects become interconnected and work smart. With the high mobility in the internet and communication technology, the IoT is one of the best solutions to integrate the automation process of the current manufacturing process [10-12].

II. LITERATURE SURVEY

A. Automation in Industries

The main concern of automation is into industries machinery and factory processing because about 33% of total manufacturing cost per unit over its production cycle is mainly expensed for the initial setting up of an automation manufacturing unit. Another crucial fact of additional operating costs is maintenance downtime. If a manufacturing unit has to be efficient for a new addition that is making available by dissimilar manufacturers, then the cost of the initial setup could be significantly increased. The main drawback in the existing technology is the inflexible communication and difficulty in applying the existing application software to a new configuration [13]. This drawback can be overcome by designing ad-hoc systems that can be retrofitted to the existing machines. Though this alternative is a bit expensive, it still saves the original equipment from becoming obsolete. Nowadays, the control of machines is different based on their process, like PLC, etc. are individually programmed for carrying out the numerous commands as process tools. The central system is responsible for the communication between the individual controls in a hierarchal network. This traditional design approach presents a major problem when used as a basis for an intelligent manufacturing control system. Industrial automation system obtained global the development on design requirement, IT amalgamation, etc. Further, automation increases the production of high-quality goods for customers and brings safety to the workplace [14-16]. As technology advances, the scope for building automation into the process is quite high and is being practiced of late in many industries. Currently, most of the manufacturing systems are in open-loop mode since they are very easy to design and implement, especially on an older type of machinery. The closed-loop control system needs continuous feedback and subsequent correction mechanism based on the feedback so that the output is more precise and stable [17, 18].

B. IoT Systems

IoT is a system-controlled smart object which is distinguishable, communication between things, able to exchange information processing, building networks of interconnected objects, or with end-users or other entities in the network. The success of IoT depends on standardization by allowing new applications to develop upon existing devices and, by allowing modern systems to be extended in parallel with existing devices, and by allowing sufficient level of ability, in such a way advanced competitive cross-domain devices and applications can be deployed, so that it can be easily manageable designed by numerous stakeholders [19].

III. PROPOSED METHODOLOGY

A. Proposed IoT Hardware Platforms

The different sections were discussing the components that form the part of a typical IoT system, their requirements, and in specific to the proposed closed-loop automation system. The aim of the proposal is to provide using less expensive hardware and open-source software to the non-professionals who are producing additional parts to the product. In this work, Raspberry Pi, a platform that enables customer programming, is considered and compared with other IoT hardware boards. Raspberry Pi is an affordable, miniature size, powerful, and learning-oriented personal computer board. Comparison of different IoT hardware boards is done with its Processor, memory, power supply, and its cost, as shown in Table 1. In comparison with few different hardware boards and IoT platforms, Udoo has good performance, but at the same time, the cost of the board is entirely high. Whereas the Raspberry Pi platform provides ultra-affordable and computer board supportable by more number of input and output devices. The internet message is the ideal platform for information exchange with various devices and thus uses an extensive range of applications [20].

Table 1. Comparison of Different IoT Hardware Boards in Market

Name	Processor	RAM	Power	Price per Node (USD)
Arduino	ATMEGA8, ATMEGA168, ATMEGA328, ATMEGA1280	Arduino 16-32 KB	7-12V /USB	30
Beagle Bone Black	AM335x 1GHz ARM® CortexA8	512 MB	5V	45
Phidgets	PhidgetSBC	64 MB	6-15V	50-200
Raspberry Pi	ARM BCM2835	256-512 MB	5V/USB	25-35
Udoo (Quad)	Freescale i.MX6Quad, 4 x ARM® Cortex™-A9 Core Atmel SAM3X8E ARM CortexM3 CPU	1 GB	6-15V	99-135

Thus, the benefits of Raspberry Pi are based on its flexibility that provides endless usage by facilitating the customers to decide it based on their financial position and requirements. Even though there are huge considerations between mentioned IoT platforms in their ideal usage, energy requirements, operating systems, etc., it can be noted that all platforms can be applied successfully as IoT hardware components that depend on one's requirements [21]. The current proposal is based on the Raspberry Pi platform and is available as a readymade board for the users to program it based on their needs.

B. Embedded Web Server

The web server which serves the web documents on request by an end-user or triggered from another device to embed is said to be an Embedded Web Server (EWS). The EWS offers rapid lively content, ease of use of the various OS, storage, and applications.

C. Protocol Layers

There are a lot of cross-layer protocols for wireless networks, such as actuator networks or ad hoc networks, and WSN. These protocols should be altered before applied to the IoT due to things in IoT often have distinct communication, computation capabilities, and changing Quality of Service demands. However, these wireless networks have similar demands for hardware and network communication. The one such node chosen for analyzing the data by automation is the Raspberry Pi microcontroller. The weaved server has the ability in machinery development, services, mobile, and security networking [22]. The Weaved technology fabric networking can be used with any hardware platforms. A website should be developed using weaved services to attain user input and to access the website user access password can be given by our requirements).

D. Adoption Cloud Computing to Medium Scale Industries by TAM

Medium Scale Industries (MSI) becomes accustomed to technology as a survival strategy. In such a process, the primary factor MSIs focus on is cost-effectiveness which drives them to opt for cloud computing for accessing their production process. Some of the external variables such as perceived external support, competitive environment, information intensity, perceived level of complexity. The high degree of comparability leads to the expected need for technological implementation and perceived affluence use of applying new technology that addresses the action aim to embrace cloud computing as a joint endeavor and eventually to consider the real purpose of adapting to the technology. The technology acceptance model is used to explain MISs' embracing of cloud computing over the perception of using its technology and perception of the affluence of using its relevant services.

IV. RESULTS AND DISCUSSION

A. An Integrated IoT and Automation - A Closed Loop Control

Products/process value in an industry can be enhanced by modern technology, which uses computer software, hardware, and firmware. While it is needed to use CNC machines to get more accurate dimensions and irregular shapes on a mass-production scale, its output can be enhanced by using the latest technologies. Hence, CNC machines are becoming more and more important in modernized industrialization. A semi-automatic machine also can be converted to a modern technology system by retrofitting. With this modern computer technology, the whole system can be converted into a closed-loop system by adding sensors and feeding back the information to further fine-tune the system. In addition to the existing machine, like a retrofitted machine or CNC, the following components are needed to make it a closed-loop automatic system.

- A microcontroller system (like Raspberry pi)
- A camera system (compatible with Raspberry Pi)
- Wi-Fi interface
- Cloud support

A Raspberry pi locates in machinery like CNC or Machine and connected to Pi compatible camera in the automation industry. The Raspberry pi could be assessed from any remote place by weaved cloud service, and the detailed schematic diagram is shown in Figure 1.

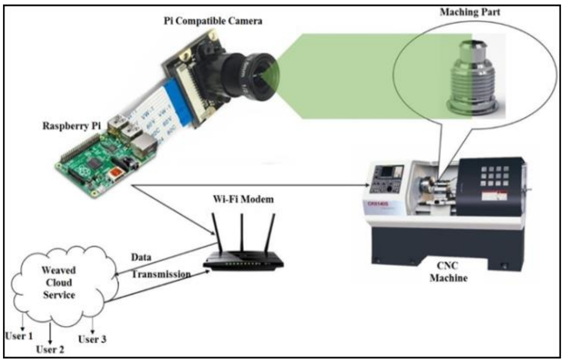

Fig. 1. Proposed Integrated IoT based Automation in CNC Machine

Pi Compatible camera continuously monitors and captures the CNC machine's critical positioning. Pi performs some predefined image processing algorithms on the captured images and compares them with the reference images. The captured images are sent to the Pi module for analysis. If there is a change in position is greater than the applicable limit, then the Pi module controls the servos of the CNC to exact the position, and the servos stop once the feedback images give no error when compared with the reference image. The warning and correction signals are sent to the remote computer through the internet-connected Wi-Fi to the weaved cloud service.

The basic processing technique used is a Pixel to Pixel AND processing. The captured image from the Raspberry Pi is converted into a Black and white (B&W) image using appropriate thresholds. The reference image used should also be a B&W image taken with the same thresholds. The normal AND operation between these B&W images gives the change in positions precisely. Better operation results from a better-processed image. The critical position components in CNC can be made black with some coating or normal paints so that the B&W image after processing gives more accurate positions of those components. Once the mismatch between the reference and the captured image occurs, the warning and correction signals are sent to the remote computer through the internet-connected Wi-Fi. The GPIO pins are linked to the program inputs of the CNC or machine to accommodate the variations. The cloud also stores the data on the production or process, the output quantity, and quality and thus provides tracking in case of issues in the future. The advantage of the cloud is that it can store a large amount of data and can be retrieved easily anytime, anywhere. The advantage of accessibility and control of data anytime-anywhere provides better control of the whole automation process.

An automation concept for evaluating the use of cloud computing by medium-scale industries is being proposed.

Cloud computing emergence has a favorable impact on all aspects except the perceived level of sophistication. Avery's notable research by Tornatzky and Klein shows characteristics to the development has the most significant effect on the acceptance of an innovation which includes public support, competitive advantage, and usability.

Table 2 Reliability of Constructs

Reliability of Composite Scores	No of Items	Inter-Item Correlation Mean	Cronbach's Alpha
Perceived External Support	3	0.623	0.949
Competitive Environment	3	0.657	0.851
Information Intensity	3	0.787	0.982
Perceived Level of Complexity	4	0.591	0.847
High Level of Compatibility	4	0.725	0.752

Hypothesis analysis builds on examining standardized paths, and the direction meaning rates determine the results of 101 specimens. The empirical findings are summarized in Table 3. Economic climate (H2) and High-reliability rates (H5) are statistically crucial for the full study. However, knowledge strength (H3) and perceived degree of sophistication (H4) did not prove statistically essential to affect cloud computing perceived acceptance. In the presented work, the composite value determines using the Hair analysis dependent average variables in scale. The accuracy of the end set of variables was checked again. Table 2 lists the final findings from a durability test. All items have strong alpha, and inter-item interaction means at Cronbach's.

Table 3 Summary of Hypothesis

Hypothesis Statement		Result
H1a	Higher levels of perceived public assistance from service vendors impact the possibility of MSIs embracing 'Cloud computing.'	Supported
H1b	Advanced stages of perceived peripheral support from Cloud providers have a positive effect on the perceived ease for MSIs to embrace 'Cloud computing.'	Supported
H2a	Enterprises are working in more dynamic markets expected to experience 'Cloud computing' acceptance.	Supported
H2b	Businesses working in highly dynamic markets get 'Cloud computing' assumed acceptance with ease.	Supported
H3a	Amount based on knowledge favorably linked to the expected 'Cloud computing' adoption	Not Supported
H3b	The information volume is linked positively perceived simplicity of 'Cloud computing' adoption	Not Supported
H4a	Increased level of Cloud computing sophistication is having a detrimental effect on expected 'Cloud computing adoption.	Not Supported
H4b	Cloud computing's perceived level of complexity impacts negatively on 'Cloud computing perceived easiness to adopt.	Not Supported
H5a	High convergence rates between Cloud infrastructure and the standards and technology of an industry impact significantly on perceived 'Cloud computing' acceptance.	Supported
H5b	High compatibility levels between Cloud computing and the technological standards of an industry positively impact on perceived ease of embracing 'Cloud computing.'	Supported
H6a	MSIs' perceived acceptance of 'Cloud computing' favorably affects the conduct of MSIs businesses	Supported
H6b	The perceived ease of use of Cloud computing by MSIs businesses has a positive impact on the conduct.	Supported
H7	MSIs behavior in adopting Cloud computing strongly affects the actual intent to adopt Cloud computing.	Supported

The indirect effect of perceived cloud computing dependency in the current conceptual model and perceived ease of cloud services transition by MSIs highlights the indirect direction towards the actual purpose of cloud computing introduced by MSIs. The results indicate that the indirect impact of perceived cloud computing adoption usage and perceived ease of adoption into cloud computing are statistically relevant. In terms of impacting cloud computing on the actual purpose of MSIs to do so, the direct path of behavioral encouragement to adopt cloud computing is statistically significant. The result report indicates that MSIs use 42.7%t of cloud computing.

B. Environmental Effects

The inward migrants who be attracted towards the life cycle due to the recent new commercial ventures like small scale industries, mini manufacturing unit which they are affiliated to develop more waste and environmental impacts by dumping their unwanted inventories. These masses dump their solid wastes, drainage, and sewerage into these water bodies. Different painting and blackening industries are sealed to environmental pollution and degradation, which would be minimized for reducing the environmental effects.

V. CONCLUSION

A novel approach to IoT-based closed-loop automation for modern manufacturing is proposed by using a Raspberry Pi-based microcontroller system, Weaved services, and CNC machines. From the observations, the following conclusions have arrived.

- This approach improves the reliability, repeatability, and accuracy by the automation by triggering.
- This automation technique increases the quality of check, consumed energy, and brings safety to the workplace.
- The system explained in this refers to a typical component output from a CNC machine and how the closed-loop automation system can support an error-free output.
- Moreover, the environmental impact will also be reduced due to the automation system as compared with manual methods. Also, the green environment may be implemented by the manufacturing industries while executing the automation system.
- Grounded on findings of the above, cloud computing external factors are the main drivers in cloud computing diffusion. Those medium-sized companies consider the hype process.
- The choice by MSIs to migrate to a particular cloud computing system relies on the expected benefit of cloud technology adoption and the expected simplicity of MSIs' use of cloud technology adoption.
- This new automation concept can be applied to any machine/component/production process with a well-defined input-output matrix.

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