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Research Paper

PROPOSAL FOR A COST EFFECTIVE AUTOMATION TECHNIQUE IN DEVELOPING INDUSTRIES USING A PID CONTROLLED LINE FOLLOWER

S Arunkumar[1]*, V Kannan[1], A Palanivel[2]

*Corresponding Author:**S Arunkumar,** ✉ arunmct04@gmail.com

A line follower robotics based automation system for a medium scale production line in developing industries has been proposed in this paper. The Cummins Line in TI Metal Forming, a developing company is taken as an example. The problem due to manual transfer of goods is studied . The cost effective and efficient technique for transfer of products in subsequent stages in the line production discussed in the paper uses a PID controlled line follower that can carry product with weight range of 10 g to 10 kg. Studies on company proceedings indicate that the production rate with the use of the described method increases by a considerable amount and can reduce the labour costs.

Keywords: Line follower robot, Industial Automation

INTRODUCTION

The small and medium scale companies generally use manpower for transfer of products from one operation to another during subsequent stages of production. Large companies use many Assembly line techniques. The balancing of these assembly lines require complex analysis of balancing with optimized and computationally feasible algorithms (Ghosh *et al.*, 1989). In order to maintain the market, many enterprises with mass production are challenged to link two strategic options: simultaneous improvements in differentiation and cost structures (Shaked *et al.*, 1987). Especially small and medium scale companies have a constraint over the use of intelligent manufacturing and assembly line techniques because of financial reasons. So there is a need to develop some cost effective technique for the survival of the companies in the competition. Intelligent

[1] School of Mechanical Engineering, SASTRA university, Thanjavur, Tamil Nadu, India.

[2] TI Metal Forming, Kakkalur, Tiruvallur, Tamil Nadu, India.

competition strategies based upon concepts of the 'Digital Factory' approach aim to overcome the traditional duality of 'cost leadership' or 'differentiation strategy' and to make both efficiency and effectiveness possible. One such technique is the use of a line follower robot based line in which the transfer of products requires minimum amount of power compared to assembly line techniques. Moreover the establishment and operation cost is less compared to advanced assembly lines. The space management is also taken care of.

PROBLEM IN CUMMINS LINE, TI METAL FORMING

So in order to design or propose automation, the nature and operations involved in the line is to be taken care of. So the Cummins line is taken as an example. The sequences of operations Involve-rolling, tig welding, drop forging, seam welding, riveting and polishing. Time period for each operation in a cycle is in minutes. The transfer of products at the finish of each operation is carried out manually. The distance between each operation is approximately 5 m. In general Cummins line is a good approximation for the production of goods like generator and motor frames, coverings boiler parts, etc., where the operation for each cycle on an average is more than 5 min. Such manufacturing lines do not require a high budget assembly lines taking into the account the space and economic considerations. But the disadvantages due to manual transfer were clear from following analysis.

In general the following observation were noted

Time for to and fro travel = 1 min

Waiting time for job completion = 2 min

(Due to inaccuracies)

Work assembly and disassembly = 1/2 min

(Including that of proper positioning in ground before assembly)

Talking and Rest time between workers = 1/2 min

All these things were on an average. So the time lag between two operations was around 4 min where the average time for an operation is 5 min.

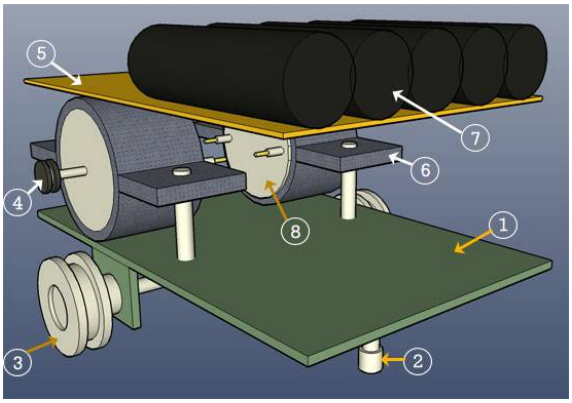
So there is a need for automation to increase the production .Moreover the automation may improve the accuracy since the mechanical movement is reduced. But the method has to be cost effective.

MATERIALS AND METHODS

Line Follower Robot

A line follower robot shown in Figure 1 is basically a robot designed to follow a 'line' or path already predetermined by the user. This line or path may be as simple as a physical white line on the floor or as complex path

Figure 1: Basic Line Follower Structure

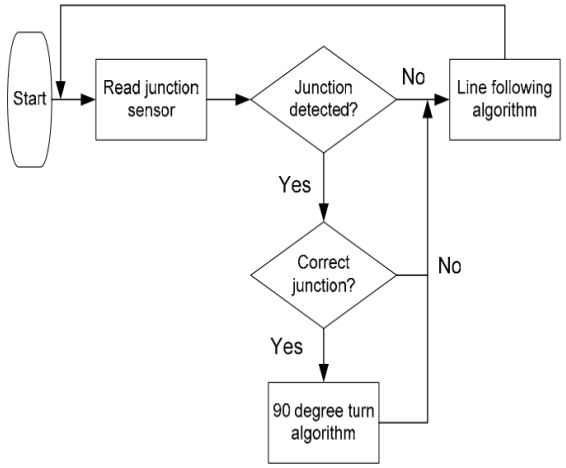


Source: (Ref[4])

marking schemes e.g. embedded lines, magnetic markers and laser guide markers. Apart from line following capabilities, these robots should also have the capability to navigate junctions and decide on which junction to turn and which junction ignore. This would require the robot to have 90 degree turn and also junction counting capabilities (Baharuddin *et al.*, 2005).

A line follower robot for a manufacturing application should in general follow the algorithm in Figure 2.

Figure 2: Line Follower Algorithm



Source: (Ref[3])

The 90 degree turn algorithm depends on the number of sensors, the type of sensor and the controlling method used.

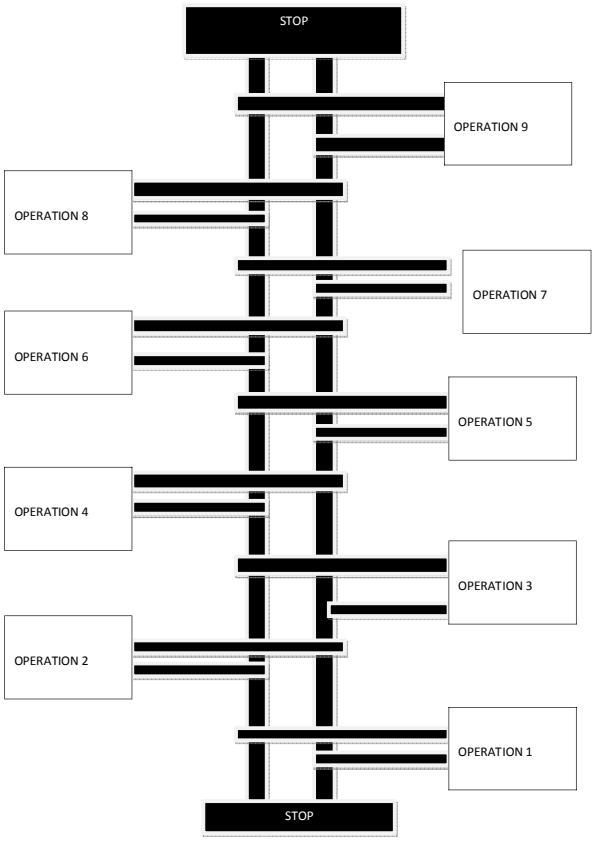
LINE FOLLOWER FOR PRODUCTION LINE

The line follower can be a good method for the production lines like Cummins where the product may weigh less than 10 kg. The constraint on the weight is attributed to the ability of motors.

PATH ASSEMBLY

The line follower assembly does not require any complex hydraulics or pneumatics or heavy motor control required for an automated assembly line. The material required for the path of the line follower to carry the material may be polished table of height 5 feet. The polished color can be black for a proper contrast from the follower's line. The number of tables depends upon the length of the line. It is recommended to have equal lengths table with edge between the two tables riveted together and polished again for smooth travel. The sequence of operations for the line can be arranged as shown Figure 3 to save time and for proper inspection.

Figure 3: Shows the Path for the line Follower



Carrier Assembly

1. Base Board

The base board can be made of thick card board or sheet metal as per the weight of the product. Care should be taken to avoid buckling which may reduce the speed of operation.

2. Wheels

Tracked wheel of about 11 cm length and 4 cm wide can be used shown in Figure 4. For heavy weight applications, it can be casted.

Figure 4: Treacked Wheels

Source: (Ref[5])

The number of wheels recommended for Cummins line is 6.

The number of wheels can recommended can be calculated approximately by the correlation

$$n = (d/15+1)/2$$

This is purely experimental and can vary for heavy weight applications.

3. Sensors

The line follower is based on IR sensor. Since the used control method is PID as discussed later, the number of IR sensor pair can be an array of 7. Two such IR arrays are recommended to in front of the two wheels. They control the wheels on the two sides.

4. Controller

A intel 8051 based microcontroller Figure 5 can be used for programming.

Figure 5: Controller Board of 8051

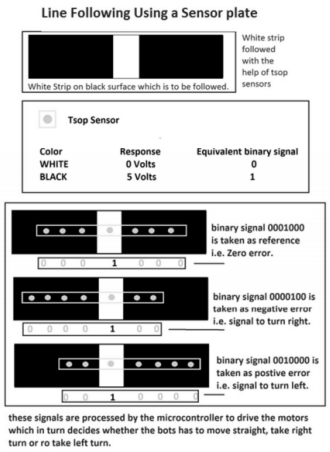
Source: (Ref[5])

PROPORTIONAL INTEGRAL DERIVATIVE CONTROLLER

In most of the production lines the product are expensive and damage to them may lead to rejection from the companies. An array of seven sensors is used for its implementation as shown in the figure. A proportional-integral-derivative controller (PID controller) is a generic feedback controller. It can be used whenever a mean position has to be achieved but the controls of the system do not react instantaneously and accurately.

The PID algorithm shown in Figure 7, takes in account the following 3 things—the existing error, the time the system has stayed away from the mean position and the possibility of overshooting the mean position. Using these 3 quantities, the system is controlled better, allowing it to reach the mean position faster and without over shooting it.

Figure 6: PID Controlled Line Follower



Source: (Ref[6])

CALCULATION

Correction Term

$$= k_p * deviation + k_j * \int deviation.at$$

$$+ k_d * d/dt\ deviation$$

RPM of Left motor =

Mean RPM – correction

RPM of Right motor =

Mean RPM + correction

Here 'k_p, k_i, k_d' is the constant of proportionality. It has to set experimentally. Maximum deviation is +/–3.

OVERALL ALGORITHM

Here S_{LL} and S_{RR} are left and right sensor arrays respectively. The overall algorithm is shown in Figures 8 to 10.

RESULTS AND CONCLUSION

This technique is suitable for developing companies to improve upon their production since the algorithm and the implementation of the above technique in industries is an easier

Figure 7: Overall line Follower Algorithm

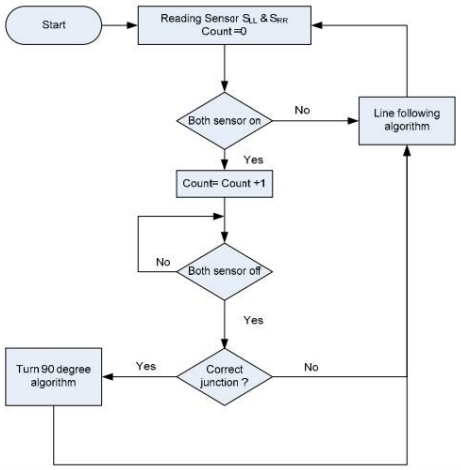


Figure 8: This Algorithm Represents the 90° Turning Algorithm

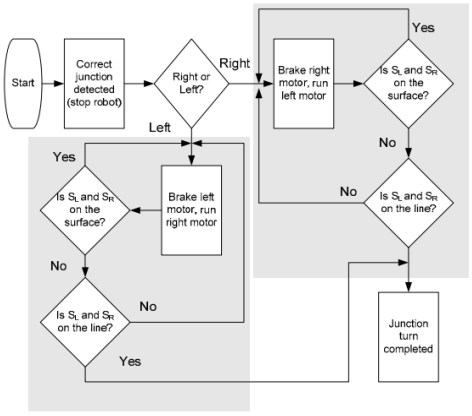
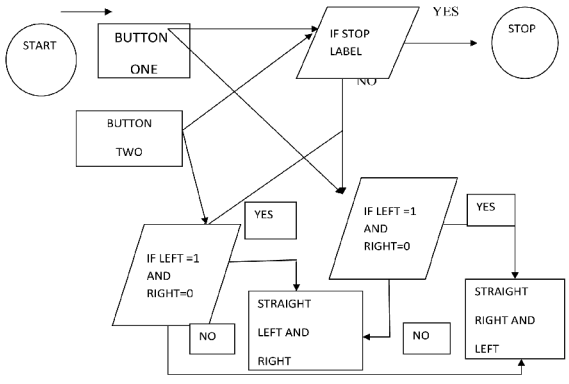


Figure 9: Illustrates the Line Follower Algorithm to be Followed in the Production Line



and cost effective task. The overall implementation of the algorithm is indicated in the flow chart.

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