Optimization Performance of a Robot to Reduce Cycle Time Estimate

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Abstract: ***In some daily tasks such as Pick and Place or Loading and Unloading application, the Cartesian robot is requested to reach with its end-effector to a desired target location. Such tasks become more complex if it has to handle multiple points in shortest travelling time and space. It this reasons that there study was conducted with the primary objective to develop a computational intelligent system that would contribute towards encouraging a productive and quality way of material handling and processing. The objective of this paper is to optimize the performance of a Cartesian (Gantry) robot to pick hot crown gear in a quenching press machine and to place our Tray Track line pallate board by Cartesian (Gantry) robot used of end-effector. In this paper where actual robot perform in an automobile industries where some distance parameter taken, there used for Aichelin Software are perform of Cartesian Robot movement used. But now in this replace on based the C++ programming & Matlab Software. We calculated our Actual Robot Cycle Time & Estimated new Cycle time to increase the productivity and increase the Efficiency of a industries.***

Keywords: **Programming, Pick and Place movement, Cycle Time, Estimation.**

1. Introduction

A Cartesian Robot is one or more principal axes of control are linear. They move in a straight line rather than rotate. Among other advantages is that this mechanical arrangement simplifies the robot control arm solution. Cartesian robots are being widely employed in industrial applications such as pick and place application lines that handle a variety of crown gear models. In order to avoid the risk factor in hot crown gear pick and place application, various steps can be taken. One of the prominent methods is by substituting the human hands with the robotic arm in handling these dangerous and hazardous environments. It is with these reasons that this study was conducted with the primary objective to design and develop a new low-cost, cycle time reduce ,high-efficiency Cartesian robotic arm for application such as loading and unloading application. A new evolutionary computation method using Dynamic Programming to control and optimize the system performance in terms of its positioning and speed that would contribute towards encouraging a cycle time reduce, improve the productive and quality process will be developed.. This population candidate controller is repeatedly grown according to crossover, mutation and other operators. The competition between different companies regarding price and performance of the Cartesian robot and control system has been the most important motivation. In case of cost saving, cycle time on robotics equipments, the solution is an alternative.

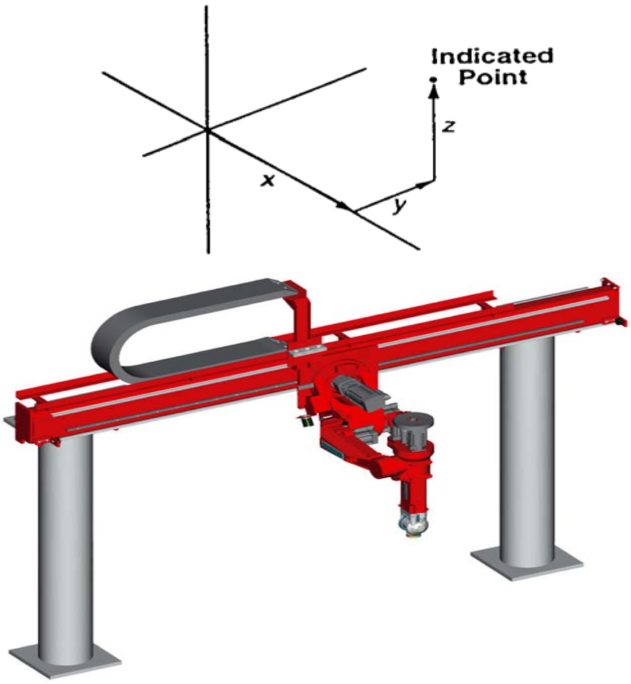


Figure 1: Cartesian Robot

1.1 Cartesian Coordinate Robot

A robot whose joints travel in right angle lines to each other, there are no radial motions. The profile of its work envelope represents a rectangular shape, also referred to as Gantry Robot.

Figure 2 (a): Project Cartesian Robot

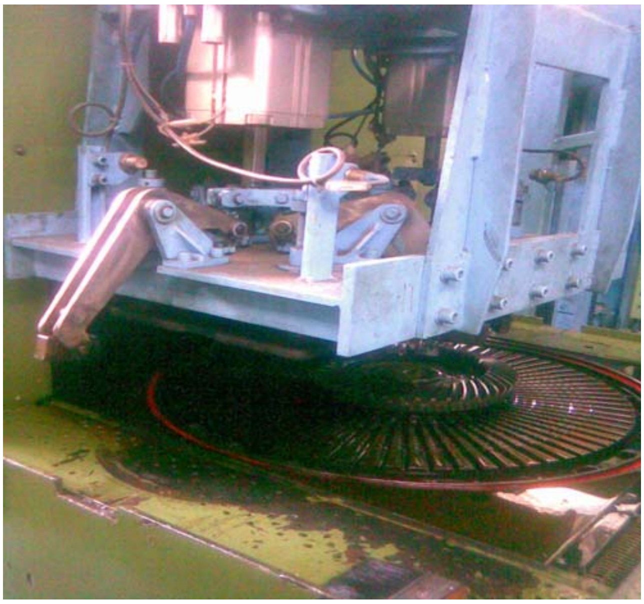


Figure 2 (b): Pick the gear by Cartesian Robot

Coordinate systems with axes or dimensions are intersecting and perpendicular (orthogonal). The origin is the intersection of the three coordinates - x, y and z axes - that locate a point in space and measure its distance from any of three intersecting coordinate planes. The coordinates are used to identify points for the positioning of end-effectors.

1.2 Controlled-Path Robot

This robot is taught its motions according to capabilities inherent in point-to-point and continuous-path systems: robot axes need not be specified, while the desired contour, acceleration, and deceleration are automatically generated. Special features of this kind of robot are path computations, programmable velocities, coordinated axis motions, ability to make changes in end-effector length, use of multi-robots, mirror imaging, and software editing and diagnosis.

1.3 Definitions of key terms

Cycle time: "Period required to complete one cycle of an operation; or to complete a function, job, or task from start to finish. Cycle time is used in differentiating total duration of a process from its run time", (Businessdictionary.com, 2010). Time required performing a cycle.

Lead time: "Number of minutes, hours, or days that must be allowed for the completion of an operation or process, or must elapse before a desired action takes place", (Businessdictionary.com, 2010).

Effectiveness: "Doing the right things to create the most value for the company", (Chase et al. 2006; 8).

Efficiency: "Doing something at the lowest possible cost…the goal of an efficient process is to produce a good or provide a service by using the smallest input of resources", (Chase et al. 2006; 8).

1.3 Level of Technology

Robots are often classified by their level of technology. These classifications are low-tech, medium tech, and high-tech. A low-tech robot is generally non servo and has only three or four axes. This type of robot has little feedback and very simple control units, and is typically used in pick and place tasks. Medium-tech robots have moderately sophisticated feedback systems and microprocessor-based control units. These robots have four to six axes. Medium-tech robots usually uses teach pendants for programming. These are the most widely used types of robots, used for grinding, drilling, milling, and loading numerically controlled (NC) machines. High- tech robots are the most sophisticated type of robot. They employ state-of-the-art technology and use large mainframe computers as control units. High- tech robots have complex feedback systems, such as optical sensors and artificial intelligence. This type of servo robot is extremely flexible and can perform a variety of tasks, such as the assembly of television sets, personal computers, and stereo systems.

2. Cartesian Robot Based Parameter on AICHELIN Software

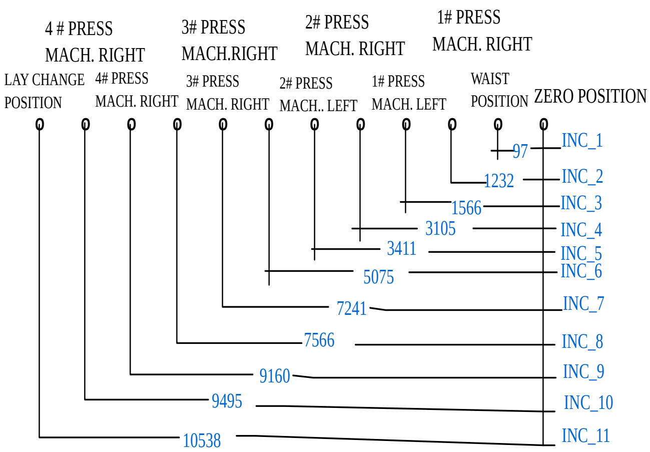


Figure 3 (b): Cartesian Robot Distance Movement

In this Software were the Calculate of distance movemet and pick the crown gear and place the tray track line board.

3. Methodology

Optimization Method by Dynamic Programming

As shown in above figure the total time taken by Cartesian robot is sum of time taken during various presses.

Suppose the time taken by the Cartesian robot in one cycle time is T.

Then our goal is to minimize cycle time
Hence the Optimization Function is as follow.

$$Tmin = \min \left[\sum_{i=1}^{17} ti \right]$$

Where reduced Robot cartsian Cycle time is depends only on distance between patch1 to patch2.Because we cannot make any anywhere else

Hence:

$$Tmin = \min \left[\sum_{i=2}^{6} \right] ti$$

Where t2, t4, t6 are constant, because these are the necessary distance which have to travel by Cartesian robot.

Now our goal reduce is only to reduce t3 and t5.

Only t3 and t5 are varying. Hence the optimization function is only depends upon t3 and t5.Means our goal is to minimize the distance travel by the Cartesian robot in time t3 and t5.

So the final optimization function is:-

Tmin =min (t3+t5);

Constraints

We have to minimize the distance travel during time t3 and t5 such that the distance travels in these times should be grater then the height of stopper placed there.

Suppose the height of stopper is hs and distance travel in time t3or t5 is d. Then our constraint for minimization function is:
d > hs
(d=Distance Travel in Time t_3 or t_5, hs=Height of Stopper)

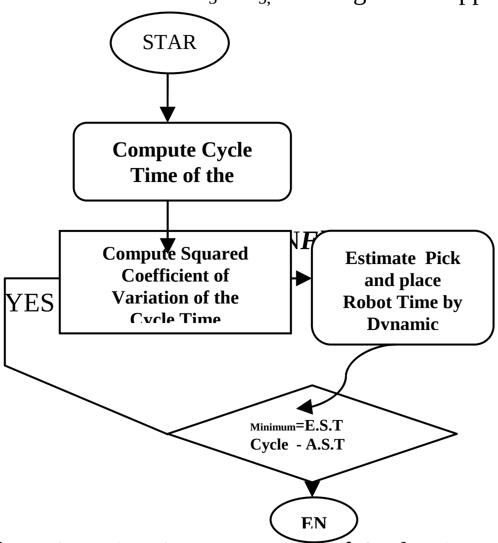
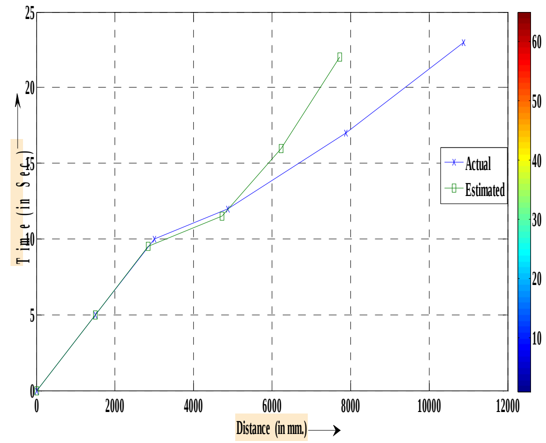


Chart 1: Estimating Parameters of Cycle Time

3.1 Simulation of Actual & Estimated Time and Distance

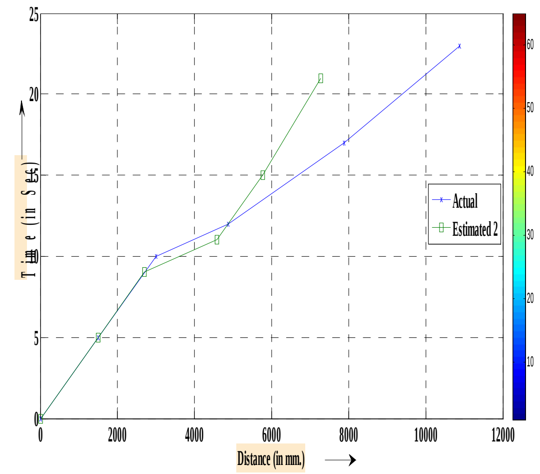
Parameter of robot movement to pick and place crown gear to evaluate of reducing time parameter of Cycle in comparison actual robot working cycle by calculating Matlab Software.

Actual Vs Estimated (1)



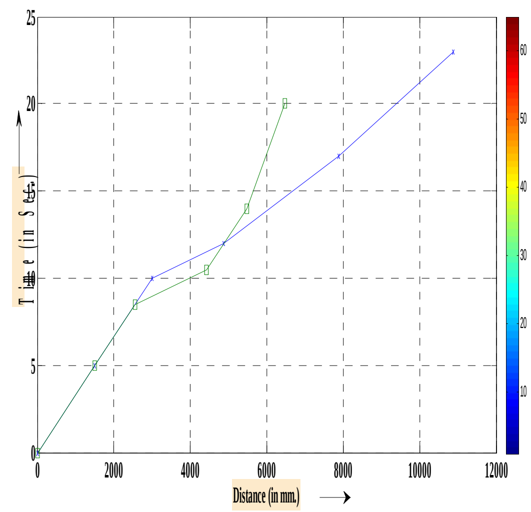
Time Vs Distance

Actual Vs Estimated (2)



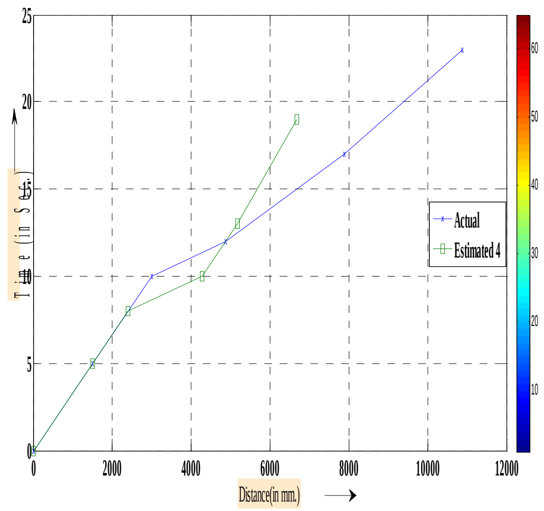
Time Vs Distance

Actual Vs Estimated (3)



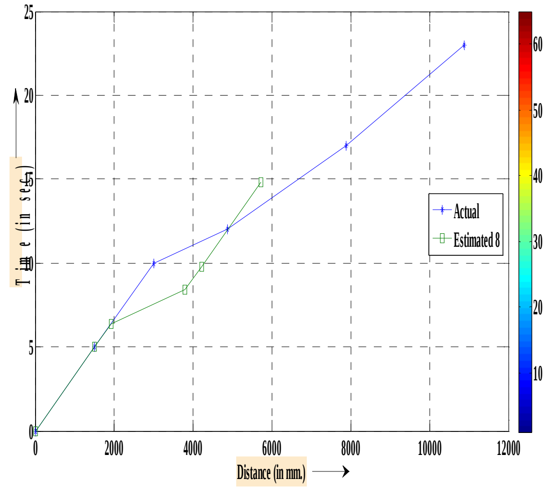
Time Vs Distance

Actual Vs Estimated (4)



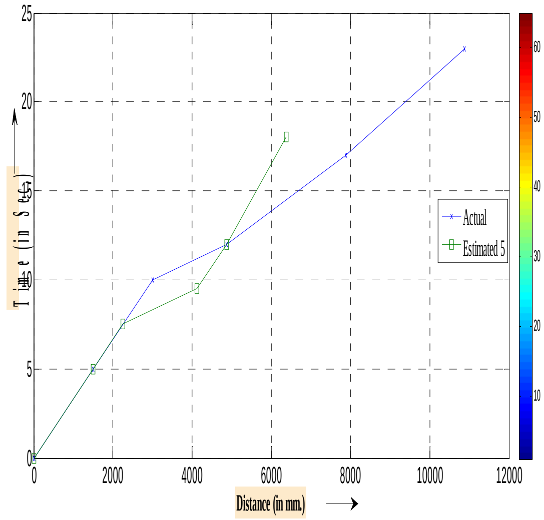
Time Vs Distance

Actual Vs Estimated (8)



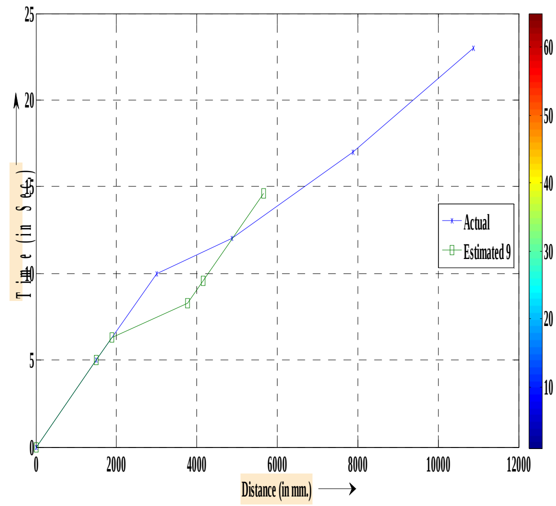
Time Vs Distance

Actual Vs Estimated (5)



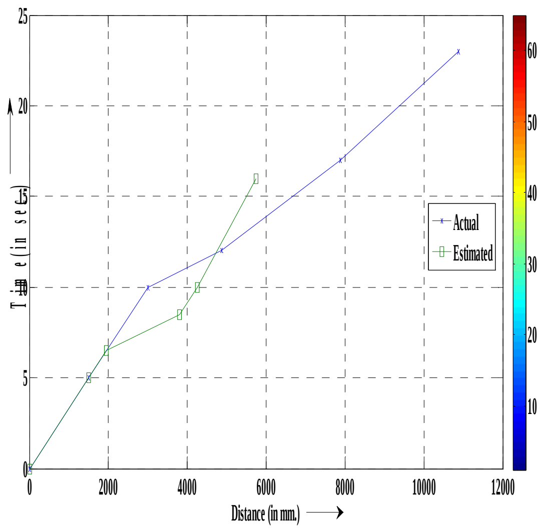
Time Vs Distance

Actual Vs Estimated (9)



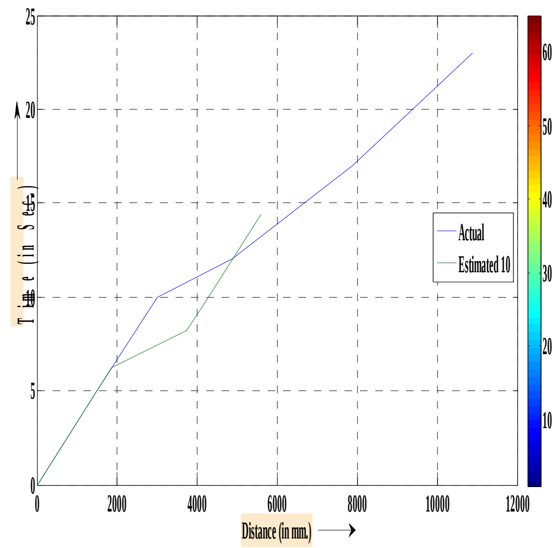
Time Vs Distance

Actual Vs Estimated (6)



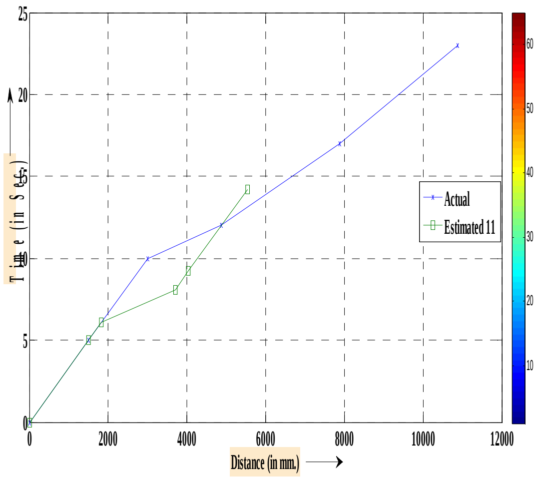
Time Vs Distance

Actual Vs Estimated (10)



Time Vs Distance

Actual Vs Estimated (11)



Time Vs Distance

3.2 Comparison data Actual VS Estimated Time:

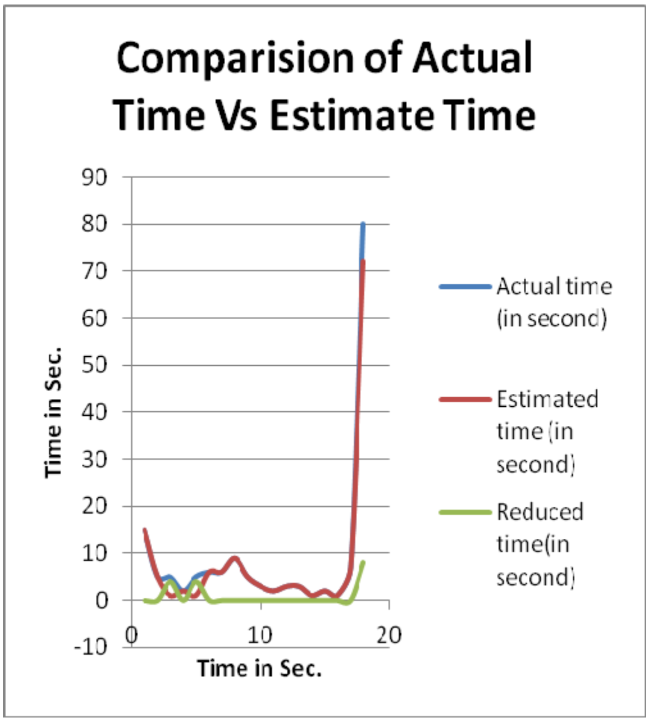
Therefore, may be the actual time working in industries and estimated time solving by C++ and Matlab Coding Programming.

Actual time (in second)	*Estimated time (in second)*	*Reduced time(in second)*
15	15	0
5	5	0
5	1	4
2	2	0
5	1	4
6	6	0
6	6	0
9	9	0
5	5	0
3	3	0
2	2	0
3	3	0
3	3	0
1	1	0
2	2	0
1	1	0
7	7	0
80	72	8

Table 1

4. Results

Our research work are to be the estimated new cycle time of a robot movement is 72 sec per process, estimated no. of Cycle increases of a robot movement is 5 cycle per hour, automatically saving a time is 8 sec by Shortest Travelling problem to reducing the travel path of robot movement.



Graph 1.Actual VS Estimates Time

5. Calculation Robot Cycle time analytical

Robot Cycle Time Based Parameter on AICHELIN Software therefore may be consumed the time 80 millisecond per cycle. But New Estimated Robot Cycle Time 72 millisecond per each one complete of cycle Consumed to Reduced 8 millisecond there for may be productivity me be increased of per cycle.

Actual Robot Cycle Time = 45 cycle completed in One hr.
Estimated Robot Cycle Time = 50 cycle completed in One hr.
Productivity Robot Cycle Time Increased = Actual C.T.- Estimated C.T.
= 50 cycle-45 cycle

Productivity Robot Cycle Time Increases = 5 cycle per hr increased.

Actual Robot Cycle Time =80 sec per each process

Cycle Process:

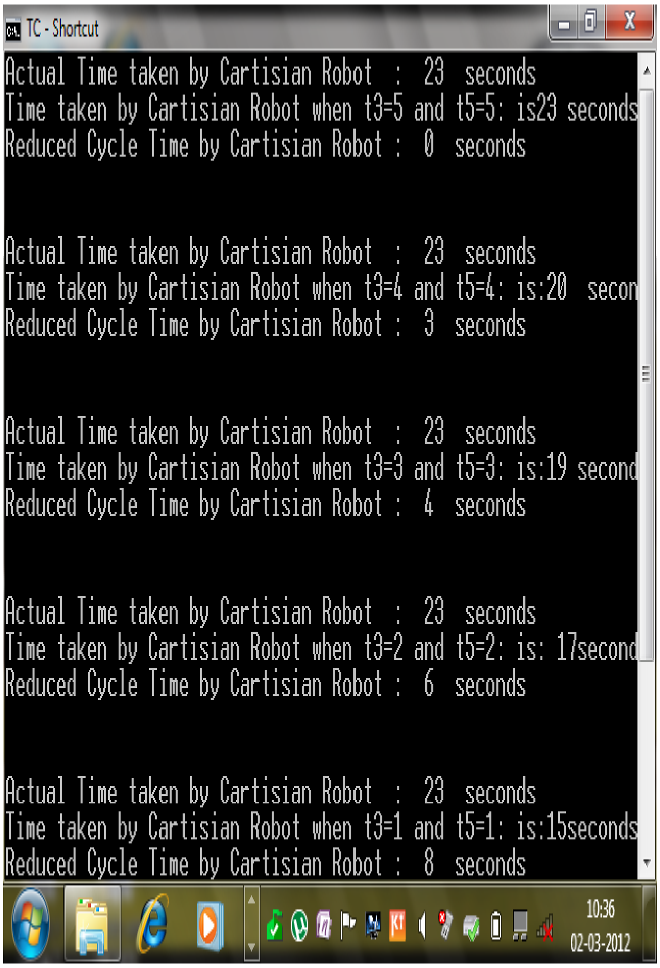
1 Robot cycle per hr. =45 cycle per hr.
1 Robot cycle per shift = 360 cycle per shift.
1 Robot cycle per day = 1080 cycle per day.
1 Robot cycle per weak= 8400 cycle per weak
1 Robot cycle per month =32400 cycle per month.
1 Robot cycle per year = 3153600 cycle per year.

Estimated Robot Cycle Time =72 sec per each process

Cycle Process:

1 Robot cycle per hr.=50 cycle per hr.
1 Robot cycle per shift =400cycle per shift.
1 Robot cycle per day = 1200 cycle per day.
1 Robot cycle per weak= 7560 cycle per weak
1 Robot cycle per month =36000 cycle per month.
1 Robot cycle per year = 438000 cycle per year.
No. of Cycle Difference= 43800 Cycle /year

The Robot increase per year cycle 43800 times, and efficiency increase per year 9%.



Output plot 1: C++ Programming for Estimated cycle time

Our industry there used aichelin software as also compare the run were run the software.

6. Conclusion

The Cartesian robot scheduling problem considered in this paper can be formulated as type of dynamic programming problem. The Cartesian based on Achleine Software to control the cycle time where to estimate our new control the cycle time by C++ and Matlab Programming to be software. The actual cycle time 80 sec completed the robot by one process but new estimated time is 72 sec. Therefore may be 8 sec reducing time to saving a time and automatically increasing the productivity 5 cycles per hr. to be increase. So, total efficiency 9 % to be increases. The main result of this paper is that the considered problem can be solved in dynamic programming, C++ & Matlab software used.

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References

[1] Ayob, M., Cowling, P. And Kendall, G. (2002) Optimisation For Surface Mount Placement Machines. Proceedings of the IEEE ICIT'02, Bangkok, 11-14 December 2002, 498-503.
[2] Ayob, M. And Kendall, G. (2002). A New Dynamic Point Specification Approach To Optimise Surface Mount Placement Machine In Printed Circuit Board Assembly. Proceedings of the IEEE ICIT'02, Bangkok, 11-14 December, 486-491.
[3] Ayob, M. And Kendall, G. (2003a). Real-Time Scheduling For Multi Headed Placement Machine. Proceedings Of The 5th IEEE International Symposium On Assembly And Task Planning, ISATP'03, Besançom, France, 9-11 July, 128-133.
[4] Ayob, M. And Kendall, G. (2003b). An Investigation Of An Adaptive Scheduling For Multi Headed Placement Machines. Proceedings of the 1st Multidisciplinary International Conference on Scheduling: Theory and Applications, MISTA 2003, Nottingham, UK, 13-16 August, 363-380.
[5] Ayob, M. And Kendall, G. (2003c). A Monte Carlo Hyper-Heuristic to Optimise Component Placement Sequencing For Multi Head Placement Machine. Proceedings Of The International Conference On Intelligent Technologies, Intech'03, Chiang Mai, Thailand, 17-19 Dec, 132-141.
[6] Ayob, M. And Kendall, G. (2004). A Nozzle Selection Heuristic to Optimise the Hybrid Pick and Place Machine. Proceedings of the 2004 IEEE Conference on Cybernetics and Intelligent Systems (CIS 2004), Singapore, 1259-1264.
[7] Ayob, M. And Kendall, G. (2005a). A Triple Objective Function with a Chebychev Dynamic Point Specification Approach to Optimise the SMD Placement Machine. European Journal of Operational Research, 164, 609-626.
[8] Ayob M. And Kendall, G. (2005b). A Variable Neighbourhood Monte Carlo Search For Component Placement Sequencing Of Multi Headed Placement Machine In Printed Circuit Board Assembly. Submitted To The Intelligent Manufacturing Journal.
[9] Ayob M. And Kendall, G. (2005c). A Weighted Nozzle Rank Heuristic To Optimise The Hybrid Pick And Place Machine. Submitted To The International Journal Of Production Research.
[10] Ball, M. O. And Magazine M. J. (1988). Sequencing Of Insertions in Printed Circuit Board Assembly. Operations Research, 36, 192-201.
[11] Bard, J. F. (1988). A Heuristic For Minimizing The Number Of Tool Switches On A Flexible Machine. IIE Transactions 20, 382--391.

[12] Bard, J. F., Clayton, R. W. And Feo, T.A. (1994). Machine Setup and Component Placement In Printed Circuit Board Assembly. International Journal of Flexible Manufacturing Systems, 6, 5-31.

[13] Bentzen, B. (2000). SMD Placement, In the SMT In FOCUS. Url:Http://Www.Smtinfocus.Com/PDF/SMD_Placement.Pdf (Sept. 25, 2002).

[14] Blum, C. And Roli, A. (2001). Metaheuristics In Combinatorial Optimization: Overview and Conceptual Comparison. Technical Report TR/IRIDIA/2001-13, IRIDIA, Belgium.

[15] Bonert, M., Shu, L. H. And Benhabib, B. (2000). Motion Planning For Multi-Robot Assembly Systems. International Journal of Computer Integrated Manufacturing, 13(4), 301-310.

[16] Burke, E. K., Cowling, P. I. And Keuthen, R. (1999). New Models and Heuristics for Component Placement in Printed Circuit Board Assembly. Proceedings of the 1999 IEEE on ICIIS99, 33-140.

[17] Burke, E. K., Cowling, P. And Keuthen, R. (2001). The Printed Circuit Board Assembly Problem: Heuristic Approaches for Multi- Headed Placement Machinery. Proceedings of the IC-AI2001, Las Vegas, CSREA Press, 1456-1462.

[18] Cavalloro, P. And Cividadi, E. (1988). An Expert System for Process Planning In PCB Assembly Line. CH2552-8/88/0000/0170, IEEE, 170-174.

[19] Chan, D. (1993). Precedence Constrained TSP Applied To Circuit Board Assembly And No Wait Flow-Shop. International Journal of Production Research, 31(9), 2171- 2177.

[20] Chan, D. And Mercier, D. (1989). IC Insertion: An Application of the Travelling Salesman Problem. International Journal of Production Research, 27, 1837-1841.

[21] Chandra, P., Li, S. And Stan, M. (1993). Jobs and Tool Sequencing In an Automated Manufacturing Environment. International Journal of Production Research, 31, 2911-2925.

[22] Chang, T. C. And Terwilliger, J. (1987). Rule-Based System for Printed Wiring Assembly Process Planning. International Journal of Production Research, 25, 1465-1482.

[23] Chen, W-S. And Chyu, C-C. (2003). A Minimum Setup Strategy for Sequencing Pcbs with Multi-Slot Feeders. Integrated Manufacturing Systems, 14(3), 255-267.

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