Pc based wireless stepper motor control and by genetic algorithm optimize its distance and time

Aritra De1, Indranil Maity2 and Averi Ghosh3

[1,2,3] Camellia Institute of Technology, Kolkata

ABSTRACT

Stepper motors is the most useable tool applied in process control, machine tools and robotics. Especially in robotics and process control, it is necessary to control the stepper motor from a remote place. In this experiment we describe how to wirelessly control a stepper motor from a remote place by using RF modules and how by genetic algorithm we can optimize its speed. In every industry this application is needed for many mechanical works and made the work easy.

Keywords: Genetic Algorithm, Stepper Motor

1. INTRODUCTION

Genetic algorithm uses some population range concept, where in between some range the fitness function is optimum. For the case of motor also some range is maintained, where the range between maximum speed/rpm & minimum range/rpm. In between that range one best fit optimum speed is to be formed where we get more efficient result. In between that range there should be some threshold value exist termed as V_{th}. In genetic algorithm we develop offspring from the original chromosome, we added subpart of chromosome1 with other chromosome & made a new offspring according to our choice, in controlling of motor speed we also modify as same manner on threshold level & form new velocity of the motor.

2. THEORY

In places with large area for example industries each location cannot be controlled manually. Moreover interconnection using wires will lead to certain hazards. So in this cases wireless control becomes preferable. The entire industry can be operated and maintained through control rooms for each blocks or sectors to make the work easy. Fig. 1 shows the block diagram for PC-based wireless control of a stepper motor. The signals from the parallel port of the PC are interfaced to the RF transmitter through an encoder. The encoder continuously reads the status of the relay switches, passes the data to the RF transmitter and the transmitter transmits the data. At the receiving end, the RF receiver receives this data and gives it to the decoder. The decoder converts the single-bit data into four-bit data and presents to the stepper- motor driver. Now, the driver performs the corresponding action, i.e., it rotates the stepper motor clockwise or anticlockwise.

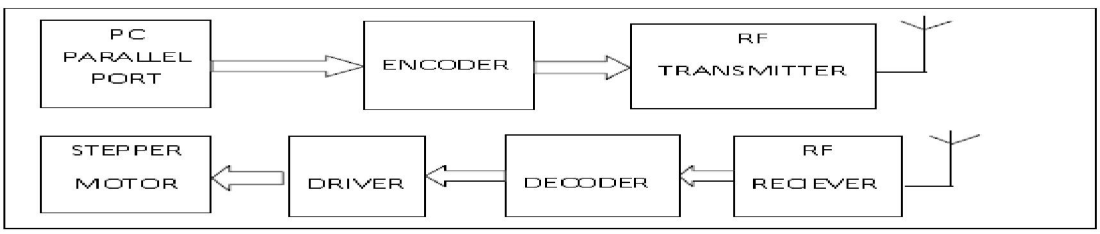


Fig1: Block diagram for PC based wireless control of stepper motor

For remote control, we have used the Holtek encoder-decoder pair of HT12E and HT12D. Both of these are 18-pin DIP ICs. HT12E and HT12D are CMOS ICs with a working voltage range of 2.4V to 12V. Encoder HT12E has eight address and another four address/data lines. The data set on these twelve lines (address and address/data lines) is serially transmitted when transmit-enable pin TE is taken low. The data output appears serially on DOUT pin. It is transmitted four times in succession

The data consists of differing lengths of positive-going pulses for ‘1’ and ‘0,’ the pulse width for ‘0’ being twice the width of the pulse for ‘1.’ The frequency of these pulses may lie between 1.5 and 7 kHz depending on the resistance value between OSC1 and OSC2 pins. The resistance values used in the circuits is chosen here for approximately 3 kHz frequency of the encoder (HT12E) at Vcc of 9V and 150 kHz of the decoder (HT12D) at Vcc of 5V. The HT12D receives the data from the HT12E on its DIN pin serially. If the address part of the data received matches the levels on

A0 through A7 pins four times in succession, the valid transmission pin (VT) is taken high. The data on pins AD8 through AD11 of the HT12E appear on pins D8 through D11 of the HT12D.Thus the device acts as a receiver of 4-bit data (16 possible codes) with 8-bit addressing (256 possible channels). Once the frequency of the pair is aligned, then on ground of any data pin of the encoder, LED1 of the decoder should glow.

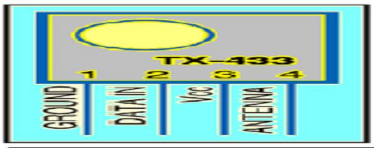


Fig2: PIN CONFIGURATION OF THE RF TRANSMITTER MODULE

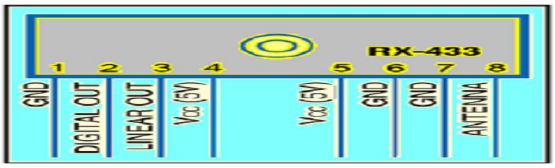


Fig3: PIN CONFIGURATION OF RF RECIEVER MODULE

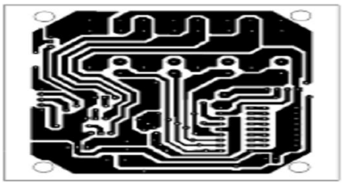


Fig. 4: Actual-size, single-side PCB for the transmitter circuit

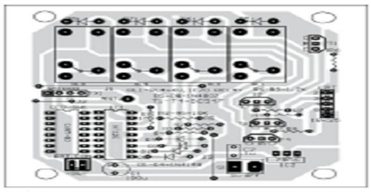


Fig. 5: Component layout for the PCB shown in fig5

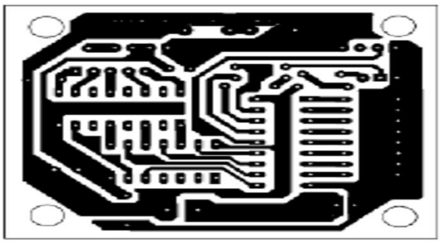


Fig. 6: Actual-size, single-side PCB for the receiver-cum decoder circuit.

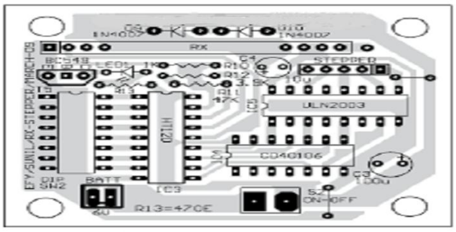


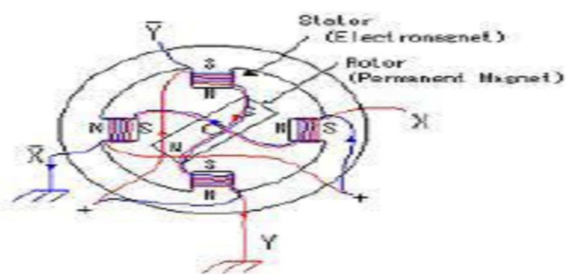
Fig. 7: Component layout for the PCB shown in Fig. 8

3. BASIC OPERATION OF STEPPER MOTOR

A stepper motor (or step motor) is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application. Stepper Motor consists of a permanent magnet rotating shaft, called the rotor, and the electromagnets on the stationary portion that surrounds the motor called the stator**.**

The torque equation for the hybrid stepper motor, which is the most popular motor, is:

$$T_A = -\frac{EI}{S} + \frac{1}{2} I^2 \frac{dL}{d\Phi}$$



4. OPTIMIZATION USING GENETIC ALGORITHM

Randomize search and optimization technique guided by the principle of natural genetic system is what we call genetic algorithm. For the case of motor also some range is maintained, where the range between maximum speed/rpm & minimum range/rpm. In between that range one best fit optimum speed is to be formed where we get more efficient result. In between that range there should be some threshold value. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover. So in the same way in case of controlling of the speed of stepper motor we modify a threshold level & form new velocity of the motor.In the computer science field of artificial intelligence, a genetic algorithm (GA) is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover. Randomize search and optimization technique guided by the principle of natural genetic system.

a. **GENETIC ALGORITHMS FEATURE:-**

- Evolutionary search and optimization technique
- Principles of evolution(survival of the fittest and inheritances)
- Work with coding of the parameter set
- Searches from a population of points
- Uses probabilistic transition rules

b. **BENEFITS OF GENETIC ALGORITHM:-**

The concepts of Genetic Algorithm is-

- Modular, separate from application.
- Supports multi objective optimization.
- Good for noisy environment.
- We always get an answer and answer gets better with time.
- Inherently parallel and easily distributed.
- There are many ways to speed up and improve genetic algorithms basic applications as knowledge about the problem domain in general.
- Easy to exploit for previous or alternate solutions.
- Flexible in forming building blocks for hybrid applications.
- Has substantial history and range of use.

Outline of the Basic Genetic Algorithm

1. **[Start]** Generate random population of *n* chromosomes (suitable solutions for the problem)
2. **[Fitness]** Evaluate the fitness *f(x)* of each chromosome *x* in the population
3. **[New population]** Create a new population by repeating following steps until the new population is complete
    1. **[Selection]** Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)
    2. **[Crossover]** With a crossover probability cross over the parents to form new offspring (children). If no crossover was performed, offspring is the exact copy of parents.
    3. **[Mutation]** With a mutation probability mutate new offspring at each locus (position in chromosome).
    4. **[Accepting]** Place new offspring in the new population
4. **[Replace]** Use new generated population for a further run of the algorithm
5. **[Test]** If the end condition is satisfied, **stop**, and return the best solution in current population
6. **[Loop]** Go to step **2**

5. BASIC MOTOR OPERATION AND RELATION WITH GENETIC ALGORITHM

Genetic algorithm uses some population range concept, where in between some range the fitness function is optimum. For the case of motor also some range is maintained, where the range between maximum speed/rpm & minimum range/rpm. In between that range one best fit optimum speed is to be formed where we get more efficient result. In between that range there should be some threshold value exist termed as Vth. In genetic algorithm we develop offspring from the original chromosome, we added subpart of chromosome1 with other chromosome & made a new offspring according to our choice, in controlling of motor speed we also modify as same manner on threshold level & form new velocity of the motor as follow: Offspring Velocity: (Vth + Δ v) But in motor instead of linear velocity we have to consider Angular velocity According to Rule: V=ωr ω=angular velocity,r=radius of circle We have to consider the tangential component the edges,so Whole distance can be written as: d=Σ2Π(rθ)0 for one complete rotation For path should be optimum or for shortest path time taken should be less, but if the distance is more time will be taken more to complete it

d ∞ t (if velocity is constant)…………….(1)

If the distance is fixed, but time is less, we have to increase speed or rotation to complete it. For more effective result velocity should be optimum.

Consider, velocity (u) ∞ t-n ………………………………(2)

Where n is some integer So,

t ∞ 1/un …………………(3)

Now we have to consider some series equations for the velocity range to expand its range for optimization, we take

$$(Vth \pm \Delta v)^n = \sum_{k=0}^{n} \binom{n}{k} Vth^k \Delta v^{n-k} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

If we expand it to becomes Un= n +n neglecting higher order terms

1/Un= n - n ………………………………….(5)

So, from equations (3) we get

, t ∞ n - n ……………………(6)

From equation (1) & (6) we get

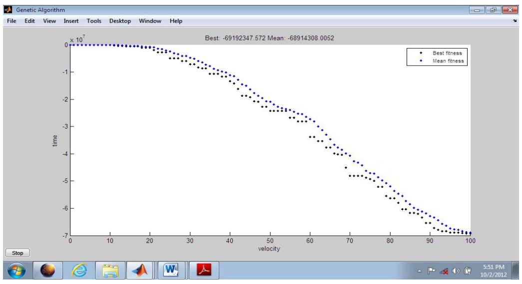
dmax ∞ n - n ………………….(A)

Time will be minimum for optimum value velocity. Final equation is:

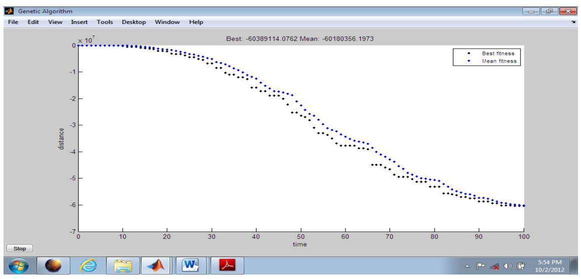
tmin ∞ n - n ……………..(B)

For a particular value of n we get the OPTIMUM SPEED of The MOTOR with respect to time & distance shown in Equations A & B.

6. RESULTS OF THE GENETIC ALGORITHM



Variation of velocity with time using genetic algorithm



Variation of distance with time using genetic algorithm

7. CONCLUSION

Randomize search and optimization technique guided by the principle of natural genetic system is what we call genetic algorithm. For the case of motor also some range is maintained, where the range between maximum speed/rpm & minimum range/rpm. In between that range one best fit optimum speed is to be formed where we get more efficient result. So in the same way in case of controlling of the speed of stepper motor we modify a threshold level & form new velocity of be operated and maintained through control rooms for each blocks or sectors to make the work easy. In case of extreme emergency manpower can be send to verify the problem. The control rooms can be more than one in number the motor. In industries each location cannot be controlled manually. Moreover interconnection using wires will lead to hazards. So in this cases wireless control becomes preferable. The entire industry can and can be many more for each section depending on the area of the industry.

REFERENCES

[1] http://en.wikipedia.org/wiki/Stepper _motor
[2] http://www.imagesco.com/articles/picstepper/02.html
[3] http:/ /www.piclist.com
[4] http://en.wikipedia.org/wiki/Genetic_algorithm
[5] http://en.wikipedia.org/wiki/ velocity
[6] STEPPER MOTORS Fundamentals, Applications and Design by V.V.ATHANI
[7] An Introduction To Genetic Algorithms by MELANIE MITCHELL
[8] GENETIC ALGORITHMS In Search, Optimization & Machine Learning by DAVID E.GOLDBERG