Profile based motion generation for actuators using LabVIEW software

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\textbf{Abstract.} Now a day’s simulation has become great tool for designing of complex problems and to get the accurate results. Simulating something will give the appropriate result without actually building the model. LabVIEW software is used for the actuator simulation and to move the actuator on the path generated by this software. Defining of the path for the actuator is known as motion profile and it can be achieved by using the motion controllers. One of the prior control techniques used is a PID (proportional integral derivative) control and it is broadly utilized as a part of criticism control of mechanical procedures in early years and continued to be the main generally utilized controller in procedure controls till today.

\textbf{Key Words:} Simulation, LabVIEW, PID controller, Motion Profiling, Actuators

\textbf{1. Introduction}

Now a day’s simulation software’s are used to simulate any kind of problem. Simulation model is the impersonation of the process of a true procedure otherwise framework after some instance [1]. The demonstration of re-enacting a bit first requires that a replica be created; this copy (model) speaks to the key merits or behaviours/functions of the chosen theoretical or physical procedure or framework. The simulation utilizes a unique model (a PC model, or a computational mannequin) to mimic the framework. PC simulations have turned into a helpful piece of scientific demonstrating of numerous common frameworks in physics (computational material science), astronomy, climatology, biology and chemistry, human frameworks in financial matters, brain research, sociology, and designing [2]. Simulation of a framework is spoken to as the execution of the framework's model.

LabVIEW is the software used to generate the various profiles and based on the profile path the actuator motion is shown using the same software. LabVIEW is a system advancement environment, much like present day C or BASIC improvement situations. LabVIEW is a graphical programming dialect that makes use of programmable blocks rather than lines of content to make
applications [3]. Rather than text (content) based programming methods, in which guidelines settle on program execution, LabVIEW make use of dataflow programming, where the stream of information decides execution. The projects created using LabVIEW are referred to as virtual instruments (digital devices), or VIs, considering that their operation plus appearance copy physical instruments like multimeters and oscilloscopes. LabVIEW consists of a complete arrangement of apparatuses for securing investigating, storing information, plus showing and also devices that helps to examine the program [4].

A controller is used to develop the required motion and these types of controllers are called as “motion controller”. The other imperative assignment of a motion controller is “motion profiling.” Motion profiling is the place the controller produces the reference position. Here, the controller gets motion parameters, for example, distance, speed, acceleration rate and deceleration fee from a host PC or HMI. From these details, the controller processes a ceaseless direction of reference positions. The path given for the actuators to move may be of any kind.

It may be as simple as the movement between two points or it may be a circular path depending on the application required. Many type of motion controller are available in the market for generating the required profile. One of the controllers which are used to generate the required motion is delta controller which is shown in Figure 1.

![Figure 1: Delta Controller.](http://www.designworldonline.com/uploads/Imagegallery/Delta-Computer-Systems-motion-controllers.jpg)

The PID controller has numerous applications in many industries and it can be used for testing up the performance of some component’s operation. These controllers are utilized in high-end compress, with position feedback offered by a magnetostrictive linear displacement transducer (MLDT) plus differential pressure feedback offered by 2 pressure sensors fixed inside the cylinder. They can be used in wind mills for blade angle control, aerospace ground test applications, paper pulp
Refiner machines, roll forming machines, power generation (turbine) for governor valve control applications etc.

Providing motion to any kind of object will always be an ongoing process and many researches are still in progress. Many parameters will come into picture while moving an object and these parameters need to be maintained to the required values. The parameters considered in this paper for the actuator motion is jerk, acceleration and velocity. The derivative of the acceleration is defined as the jerk which directly influences the motion of any kind of object, as the value of jerk minimizes the motion becomes smooth. The advantage of reducing the jerk is minimum stress can be induced in the actuators.

In order to generate the path for the actuators, the controller designed for this application is PID controller. The controllers are designed based on the operation required for the particular application. In early days, a general type of PID controller was introduced for fulfilling the effective controller standards and conditions [5]. The decoupling of the set point reaction from the weight reaction is also done for rearranging the outlines and tuning of the controller [6]. The frequency domain PID controller outline strategy is also determined by exhibiting a far reaching treatment of integrating procedures which utilizes the wanted reference signal direction as an execution particular and comprehends for the PID controller parameters in the frequency space [7]. An effective and strong outline strategy is built in the later years for ascertaining ideal PID controllers for programmed voltage controller framework by utilizing support learning to demonstrate productive results regarding optimality, calculation trouble and less delicate to the extents considered for the configuration variables [8].

The work is focused on to the actuation of actuators based on the profiles generated. Generating profiles is nothing but defining path for the actuators to move to the specified distance with the given velocity and acceleration. The acceleration and deceleration of the curve depends on the profile generated. The profiles generated are exponential, polynomial, power, S-Curve and linear functions. The actuator will follow the path generated by the profile generator. The controllers are used to control the motion of the actuators based on the profiles generated. In order to provide motion for the actuators the software approach is found feasible by using a simulation method of finding the solution. Computers are used for creating the simulation of these actuators.

2. Design

The profile based motion generation designing is mainly divided into four blocks as shown in Figure 2 and these blocks are interrelated with each other to provide the smooth motion with reduced jerk. The blocks involved in designing are profile generator, PID controller, actuator simulation and feedback simulation block.

![Figure 2: Block for controlled motion of actuator.](image-url)
2.1 Profile Generator

The first block in designing is profile generator. Profile generators are nothing but the time based motion commands to the PID. The profiles are fed to the PID controller in order to move the actuator in specified path as defined by profile generator. Various profiles can be generated based on the system and application requirements. The profiles generated for this work are: Exponential Function, Polynomial Function, Power Function, S-Curve and Linear Function.

2.2 Proportional-Integral-Derivative (PID) Block

The next is PID block where it takes the command from profile generator. One of the vital general methods of controlling available in the market is the PID controller and this type of controller has the highest quality manage dynamics including no steady state error, speedy response (short ascent time), zero oscillations and higher stability. As the command generated will be smoother the controller produces required motion with controlled velocity. The values of P, I and D gains are chosen in such a way that the target is reached with given speed and without much disturbances. The D gains are usually zero which means they are ignored by assuming that the system is with sufficient damping factor.

2.3 Actuator Simulation

The next is the actuator simulation block and an actuator is a kind of motor that is liable for relocating or controlling an instrument or system. It is worked by means of a source of energy, most of the time electrical current, hydraulic fluid stress, or pneumatic strain, and converts that power into movement. Mainly there are five types of actuators: hydraulic, pneumatic, electric, thermal or magnetic and mechanically operated actuator. This classification is made based on the actuator working like if the actuator consists of fluid motor or cylinder then it is known as hydraulic actuator or if it involves the application of compressed air then it is known as pneumatic actuator. Hydraulic actuators are used where the heavy power application is needed like in lifting heavy components for example JCBs. Hydraulic system has the disadvantages like oil leakages. As the air is readily available in nature the pneumatic system is found to be very cheap but it cannot be used for heavy lift applications. An actuator is the component by which a control framework follows up on a domain and the control framework can be straightforward (a fixed electronic or mechanical framework), programming based (for example a robot control framework, printer driver), a human, or other information. The durability of these actuators is determined by every individual manufacturer, which depends on the quality and usage. This block mainly consists of the designing done for the actuator motion.

2.4 Feedback Simulation

It is necessary to keep the track of the actuator for every cycle. Hence feedback simulation logic is created to know the previous position of the actuator. A feedback framework is one in which the yield sign is inspected and after that sustained back to the input to shape a mistake flag that drives the framework. Feedback means when yields of a framework are engaged rear as information to a feature of a shackle of situations and end results that forms a circuit or loop. Feedback control is a manipulate machine that utilizes data from dimensions (measurements). In a feedback control process, the outcome is detected. The feedback helps to store the previous iteration values which will help in giving the accurate results.

The effects of various parameters are considered while designing the profiles. Some of the parameters considered for this work are jerk, acceleration and velocity. How these parameters will vary with respect to the profiles generated can be given in Table 1. The values of jerk, acceleration and velocity are chosen in such a way that the target is reached with the given speed and without many disturbances.
Table 1: Effect of jerk, acceleration and velocity on the profiles generated.

| Parameters         | Jerk  | Acceleration | Velocity |
|--------------------|-------|--------------|----------|
| Exponential Function| High  | High         | High     |
| Polynomial Function | Controlled | Controlled | Controlled |
| Power Function     | High  | High         | High     |
| S-Curve            | Controlled | Controlled | Controlled |
| Linear Curve       | High  | High         | Controlled |

Like the above parameters how they are considered for the smooth motion of actuators, the PID parameters are also chosen in the same way. These values are chosen based on the trial and error method performed while conduction of the experiment. In practice, the D gains are zero which means they are ignored by assuming that the system is with sufficient damping factor.

3. Simulation Results

The various profiles generated using the LabVIEW software is as shown in below graphs. To generate the neat waveforms lot of mathematics is involved which plays a background role known as back-end designing. The output waveform for the exponential profile is as shown in figure 3 and for the actuator motion if this path is chosen then the jerk, acceleration and velocity are high. The same is for the profiles generated using power and linear functions which is as shown in figure 5 and 7. In order to get the smooth motion of the actuators the polynomial and S-curve profiles are best suited as the jerk, acceleration and velocity are controlled here. The waveform for polynomial function and S-curve generated using LabVIEW software is as shown in figure 4 and figure 6 respectively.

As it can be observed from the waveforms of figures 3, 5 and 7 generated, there is a sudden rise or fall in the curve hence high acceleration and deceleration can be seen for the exponential, power and linear functions. Because of which the actuator experiences a sudden jerk and the speed with which the actuator is moving will be more. The jerk and high speed of the actuators can be controlled using the polynomial function and S-curve. As seen from figure 4 and 6 the waveform has a smooth acceleration, hence the actuator experiences reduced jerk and moves with the controllable speed.
Based on the above profiles generated the actuator will move in the desired path. The actuator motion for the corresponding profile generated using LabVIEW software is shown in below figures. Figure 8 shows the initial position of the actuators i.e. at zero position and figure 9 shows the actuator position when they are moved to their final distance of the given value. Figure 8 and 9 consists of the detailed simulation designing as explained in design section. The generation of the profile and the actuator motion based on the path generated can be shown on the same front panel of the LabVIEW software using tab control option. The tab control option used here consists of two pages. Page 1 shows the output of various profiles generated and page 2 indicates the output of the actuator motion based on the path generated in page 1.
Figure 8: Actuators at zero position.

Figure 9: Actuators motion with the profile generated.
4. Conclusion

It is shown graphically the outputs for all the functions i.e. exponential, polynomial, power, S-curve and linear functions. Based on the PID parameters the output can be controlled according to the system and application requirement. The output of the system can be varied by changing the parameters of PID controller. The higher quality solution can be obtained with better computational efficiency.

It is observed from the simulation results that the S-Curve is best suited to generate the smooth motion with reduced jerk and controllable velocity. The name S-curve is because of the S-like situation of the bend as it can be seen from the graph the curve is compliment towards the starting and end and more extreme in the centre, which is natural for usually more activities. At the start of the waveform it speaks to a moderate increase in the plot, consider however fast begin, while the finish talks about deceleration because the work runs out.

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