

# Chapter 1

## Introduction

### 1.1 Introduction

Robotic structures are reprogrammable, multifunctional manipulators designed typically to move material, parts, tools, or specialized devices through various programmed motions to perform a variety of tasks. Therefore a robotic manipulator represents a complex system that combines knowledge from different disciplines including mechanics, machine design, electronics, electric devices, computer engineering, etc. A team that develops such system needs to work on all issues related to these disciplines concurrently. A main objective of this project, therefore, is to employ the knowledge we attained throughout the course of our study to develop a robotic prototype that perform specific tasks. Since robotic manipulators may be classified, according to their robotic kinematic structures, into parallel or serial robots, we chose in this project to adapt parallel kinematic structure for our developed prototype for some reasons that will be briefly discussed next.

The kinematic structures of most robotic manipulators used in the industry are open kinematic chain structures known as serial robotic structures or manipulators. Only relatively few commercial robots are built around the concept of closed kinematic chain

(parallel) structures. Nonetheless, increasing interests in parallel robots points to the potential embedded in these structures, which has not yet been fully exploited. Such potential rely on clear advantages associated with parallel robots as compared to serial ones which are listed below:

- Higher payload-to-weight ratio since the payload is carried by several links in parallel.
- Higher accuracy due to non-cumulative joint error.
- Higher structural rigidity, since the load is usually carried by several links in parallel.
- Location of motors at or close to the base.
- Simpler solution of the inverse kinematics equations.

Parallel kinematic structures however suffer from a number of limitations including smaller work volume, singular configurations and a more complicated direct kinematic solution (which is usually not required for control purposes).

In the following section, we introduce the mechanism that we are designing and manufacturing in this project that is categorized under parallel robots.

## **1.2 Project Overview**

In this project, we are required to design and build a two degrees-of-freedom robotic prototype that works on the concept of parallel manipulation. The prototype will perform two main functions:

The first function is to plot primitive segments, including linear and circular segments, in the x-y plane. The second function is to use the prototype as positioning device that position a drilling tool in the x-y plane to drill the holes of a manufactured Printed Circuit

Board (BCP). To accomplish these tasks, our prototype will utilize a mechanism driven by two linear actuators to position the end-effector point anywhere in the  $x$ - $y$  plane.. The system consists mainly of two rotary-to-linear mechanism that converts the angular motion of two stepper motors to linear motion. The mechanism used for this purpose will be a screw-nut mechanism that is shown in Figure 1.1.

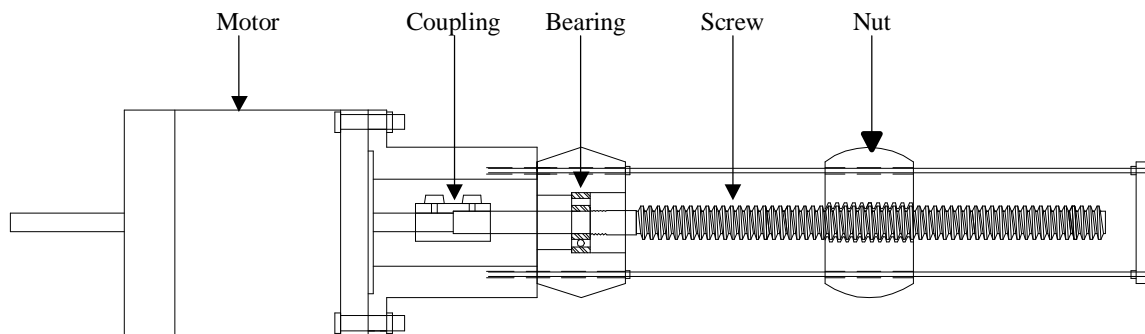


Figure 1.1 Screw-nut mechanism driven by electric motor

We opted to use stepper motor to derive this mechanism due to a number of features, the most important and the most related to our aim is that the speed of the stepper motor and the position it provided can be accurately controlled without the need of a feed back control system with the assumption that the motor will not stall or slip.

Stepper motor torque is limited by its holding torque, which is the amount of torque they can hold without slipping with the coils energized at the rated voltage. This is why the stepper motor usage is limited to applications requiring affordable and accurate positioning and/or speed control (printers, small scale CNC machines, etc) where the load is not an issue to care about. The case encountered in our project.

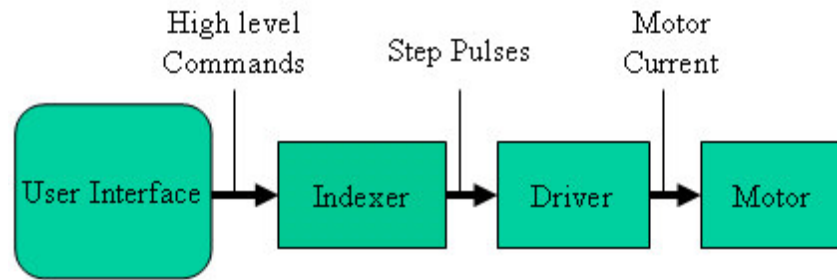


Figure 1.2: Stepper motor system

Figure 1.1 demonstrates the stepper motor system. It consists of the following items:

**User interface:** It is the means at which the user can input characteristics of motor motion including, number of pulses, rotation speed and direction. The interface will control the functioning of the indexer.

**Indexer:** also called a controller, a microprocessor or a computer. It will send step and direction signals to the driver through the printer parallel port.

**Stepper motor drive (amplifier):** it converts the step and direction signals from the indexer to electrical pulses and uses them to energize the motor windings.

**Stepper motor:** The motor shaft is rotating due to energizing the coils with electrical signals sent from the motor drive.

An electric actuator is a device that can be elongated/shortened using a nut-screw system, via transmitting the rotation of an electric motor to the screw. Functioning of the actuator is discussed thoroughly in chapter 2.

The main deliverables of the project are:

1. Searching the algorithms and hardware needed to control stepper motors through the PC parallel port.
2. Developing the kinematics relations that we are going to use in the control algorithm.
3. A design drawing for the actuator to be built is to be proposed.

### **1.3 Scope and Organization**

Work was divided into three tasks. These tasks were conducted through the project period in a parallel and integrated manner. These three work categories are:

1. Mechanical design of the actuator task:

This includes studying the conceptual kinematics of the actuator. Proposing preliminary designs and proposing the details of design, manufacturing and assembly.

2. Stepper motor testing and wiring task:

This includes studying and practicing using the electrical components required in conducting test and experiments on the stepper motor system. Drawing and implementing the wiring diagrams of the different electrical circuits included in the system.

3. Parallel port interfacing task:

This includes searching, studying and practicing interfacing of the printer parallel port to send user commands to the stepper motor system. Writing interfacing codes, testing the codes, analysis of the kinematics of the motion along the axis of the screw and in 2D, building a user friendly interface, and controlling the drawing and drilling mechanisms are all tasks implemented under that general title.

This report was also organized on the bases of the three main tasks mentioned above. The technical core includes, in addition to the introduction and conclusion, three chapters;

each chapter discusses one of the main tasks thoroughly. Titles and numbering of chapters and sub-chapters are clearly indicated in the table of contents.