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DATA OBSERVATION IN CNC MACHINES USING AI TECHNIQUES

# **INTRODUCTION OF CNC MACHINES**

As an important part of the product quality control, the quality visual inspection of products is gaining more and more attention in the industrial manufacture. It aims to ensure the product quality by detecting defects by visual means. In the production process, the low product quality will do no good but harm to any of the participants. On the one hand, the quality of products will affect the production efficiency since products with poor quality will crimp the sales and they are only a waste of raw materials and costs money. On the other hand, product quality relates to the products in the market share and the credibility of the factory. Only products with high-quality can obtain the long-term occupation of the market. However, in the process of quality visual inspection, many factories still use artificial methods to do defect detection, which rely heavily on the manpower and consume much financial resources. Since a person’s own energy is limited and the human inspection job is trivial, workers with long-time continuous work may reduce production efficiency because of fatigue, and this will lead to the problem of product quality testing and heavy economic losses brought by the human error. To this end, it is urgent to bring automated defect detection into the production process [1].

Since the 4th Industrial Revolution, the smartization of the manufacturing industry using information and knowledge has been rapidly growing. Computer numerical control (CNC), machining center tool (MCT), and injection molding machines are typical production equipment applied to smart factories. Various sensors are installed and operated in the factory for detecting defects and maintaining the production facility. It is possible to build a monitoring system using data gathered from sensors. Sensors are used for predictive preservation of production machines, optimization of manufacturing processes, and real-time abnormality detection using applying data analysis, machine learning and deep learning technology. According to these changes, various research studies have been conducted in academia based on sensor data. Data collected from the sensor data are stacked up as big data and stored in a data center at the manufacturing site or in a cloud environment. Owing to the rapidly growing computing power the analyze of big data has recently been in the spotlight [2].

However, there is a fatal problem with sensor data gathered from manufacturing facilities. The state of big data from most of the manufacturing facilities is more imbalanced than that of normal data. Furthermore, it is not easy to gather abnormal data unless the equipment intentionally fails because the tools are replaced periodically based on the experience of expert workers[2].

CNC machines are widely used in manufacturing facilities to manufacture products according to the desired shape and conditions by entering predefined commands. The operating principle of CNC begins with direct coding through a CNC machine or PC with a CNC programming application. The program or order transmitted and executed to the CNC machine performs the process according to the program and the desired form. Depending on the process, various methods are used, and the types of data collected are different. The collected data is representative of vibration, temperature, speed, power, current, and noise. Various research studies have been conducted to detect abnormalities in the mechanical system of CNC machines. According to previous studies, vibration, power, and noise data are typical data used to prove the cause of failure of CNC machines. Previous research using motor vibration data of production facilities proposed a technique to solve the imbalance from collected data and detect outliers based on the encoder-decoder-encoder generator based on the generative adversarial network (GAN)[3].

## Motivation and Objective

Timely determination of the condition of the equipment and its maintenance has been and remains an important task in any production. Moving to the concept of Industry 4.0 and digital factories leads to the fact that during the operation of equipment, huge amounts of data are stored.

The purpose of this research is to develop an AI model for the automatic observation and analysis of CNC dataset by using unsupervised machine learning techniques.

We got dataset from a private manufacturing company named HANTEC situated in Chugwon a city Korea Republic.

# **Background Knowledge of CNC Machines**

## Some Basic Definitions

1. **CNC:** Computer Numerical Control – A computer and [CAM software](https://www.autodesk.com/products/fusion-360/blog/computer-aided-manufacturing-beginners/) are used to automate, control, and observe the motions of a machine using digital data. The machine might be a robot, router, lathe, grinder, welder, sheet metal stamping machine, laser or waterjet cutter, or any number of other devices. The computer is often an on-board specialized controller for bigger industrial machinery. However, the computer can be an external PC for machines that are more suited to hobbies or with certain retrofits. To move and control the machine axes and carry out the preprogrammed movements, the CNC controller collaborates with several motors and drive components.
2. **Desktop CNC:** There are a lot of smaller desktop CNC machines designed for model makers and hobbyists. These are often less costly, slower, less accurate, less stiff, lighter, and less rigid than their industrial equivalents, but they work well for milling things made of softer materials like plastic, foam, and wax. Some desktop computers may operate quite similarly to a printer. Others may even have specialized CAM software and their own closed command system. A few will also take input in the form of regular G-code. Certain desktop industrial standard machines have specific controllers for performing fine tiny operations.
3. **CAM:** Computer-Aided Machining or Manufacturing – This is the process of using different software programs to generate toolpaths and NC code for a CNC-operated machine based on data from 3D computer models (CAD). The combination of the two is frequently referred to as CAD/CAM.

It should be noted that CAM only generates code for the CNC machine to follow. Additionally, it does not import your CAD model and automatically generates the appropriate NC code. In order to execute the program, create machining strategies, and know which tools and operations to employ in each circumstance to produce the best results, CAM programming, like 3D modeling, requires knowledge and expertise. While there are certain straightforward programs that a novice user can pick up and use without too much trouble, more complex models require time and financial commitment to become skilled[4].

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Figure . CNC machining

## Types of CNC Machines

There are different kinds of CNC machines. Some of the most common types of CNC machines are given below:

### **CNC Milling Machine**

One of the most common CNC machines are mills, which include integrated tools mostly used for drilling and cutting. In comparison to other CNC equipment like CNC routers, CNC milling machines are relatively big and costly. The workpiece is placed inside the milling machine, and then the computer takes over.

Every action and movement of the spindle and tools is guided and instructed by the computer code to accurately cut and transform the workpiece into a planned bespoke item.

Some of the typical tasks that a CNC milling machine may carry out include tapping, turning, drilling, milling the face, and milling the shoulder.

Configurations for CNC milling machines range from three to six axes. The three axes in the simplest 3-axis CNC stand for the motions of the X axis (horizontal), Y axis (horizontal), and Z axis (depth). Some of the well-known manufacturers of big CNC milling machines are Okuma, Haas, and DMG Mori.

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Figure . A CNC Milling Machine [5]

### **CNC Lathe Machine**

### The capacity to rotate materials while in use defines lathe CNC machines. They are shorter and more compact than CNC milling machines because they have fewer axes. A lathe that controls and transmits material to the computer programmatically is at the heart of CNC lathe machines. Due to its quick and precise operation, it is now a lathe that is frequently utilized.

After initial setup, a semi-skilled person may readily operate it. The capstan and turret are two examples of mass-produced items that utilize this kind of lathe. However, there is no automated feeding mechanism.

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Figure . A CNC Lathe Machine [6]

### **CNC Drilling Machine**

Like conventional drilling machines, CNC drilling equipment makes holes in a stationary object using a spinning cutting tool. However, CNC drilling machines are more precise and adaptable than conventional drilling machines since they rely on CNC technology. For instance, holes may be produced by CNC drilling equipment with tolerances as tight as 0.001mm. Additionally, they work well with a variety of materials, including wood, plastic, and metal. Additionally, many CNC drilling machines have a tool turret that can hold several drill bits and enable rapid switching between them during production. If you want to create hubs, gear blanks, and machined shafts, you should use CNC drilling equipment.

### **CNC Laser Cutting Machine**

In their capacity to cut through strong materials, CNC laser cutters are similar to CNC [plasma](https://en.wikipedia.org/wiki/Plasma_(physics))cutters. But unlike a plasma cutter, which employs plasma, a CNC laser cutting machine uses a powerful and highly focused laser to do the work (ionized gas). CNC laser cutting machines often offer a greater degree of precision and a better surface quality when compared to CNC plasma cutters since lasers have a smaller point of contact and spread than torches. The laser power may be adjusted to readily cut through material depending on the density and toughness of the material. The material shape is frequently in the form of a sheet in CNC laser cutters. The material is then sliced precisely by the laser beam moving back and forth across it. To make the precise cut, the laser’s heating action vaporizes or melts the material.

When compared to other cutting devices, CNC laser cutters may frequently generate a range of patterns. Frequently, the cuts and edges generated are so exact and clean that they don’t need any more polishing. As a result, CNC laser engravers are frequently used to make parts and engrave machine parts.

CNC laser cutting machines frequently employ lasers like CO2 and neodymium (Nd)-doped yttrium-aluminum-garnet (Nd:YAG). OMtech, Flux Beamo, and Glowforge are some popular brands of CNC laser cutters.

### **CNC Grinding Machine**

It is a finely crafted performance tool that separates metal from metal using a revolving wheel. Camshafts, ball bearings, transmission shafts, and other functional items that need an exact and precise finish are frequently ground on CNC grinding machines. Cylindrical objects are frequently produced with a CNC grinding machine. Other kinds of workpieces can also be produced by a grinding machine. “CNC” stands for computerized numerical control in CNC grinding machines.

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| A picture containing power saw, tool, miller  Description automatically generated  Figure . A CNC Drilling Machine [7] | Figure . A CNC Laser Cutting Machine [8] |

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Figure . A CNC Grinding Machine

## Applications for CNC Machining

### **CNC Machines Are Repeatable**

The main advantage of CNC punching is the ability to produce as many copies of a design as your materials will support after the design has been defined. Once the application is installed, you can simply save it and utilize it whenever you choose, whether you’re creating plaques, carved signs, decorations, or even automotive components.

### **Dental Supplies**

Although wood and sheet metal are frequently made using CNC services, they can produce much more. Even dental crowns and implants may be carved out using CNC software since the technology is so accurate.

### **Armaments**

You may be aware of the debate around 3D printers because of their capacity to produce weapons without serial numbers. However, CNC machines have existed for a far longer time and have always had that potential.

The military and defense sector frequently employs CNC manufacturing to produce different types of weaponry and equipment in addition to guns. The entire industry gets a lot of its equipment from CNC production.

### **Construction**

CNC punching can be useful quite a bit when it comes to building. You might not anticipate some of these.

Even the most accomplished carpenters would struggle to match the level of accuracy needed for some works, particularly when working on pre-existing structures.

### **Transportation**

CNC technology is used in various ways by the aviation, railroad, and automobile sectors since it provides such a wide range of services.

To guarantee that every component of the plane operates as it should while you are thousands of feet in the air, every element must be made with high accuracy. For this reason, the industry has traditionally relied on machining services.

### **Niche Production**

CNC machines can do almost anything. A CNC machine can produce practically anything that needs to be made from the correct amount of any material. NC technology has raised the bar for manufacturing in all specialized fields and fashions and is only becoming better. Whatever your demands are for production, a CNC can meet them.