

Robotics in hand objects manipulations by vibrations

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Introduction

Robotics has been expanded rapidly in recent years. The use of robots with artificial intelligence is becoming common in a growing number of industries.

In the field of robotic arms, there is a need for the implementation of in-hand manipulations. There are many different solutions to these manipulations, mostly complex solutions of modern and sophisticated hands at high prices. Intra-manipulations have many uses in many industries. The high cost of the proposed solutions makes it difficult to use them extensively.

In the study I participate in, we use simple and inexpensive robotic hand for in-hand manipulations. The operation is possible by using a vibration motor inside the finger that holds the object. The vibrations allow control of it within the grip. For example, using force vibrations in the finger to perform a credit card slipping for repositioning.

During the project, I built program that calculate displacement at the fingertip of the robotic hand/finger. Based on classical beam theory, the finger is modeled as a harnessed beam with a point load at the end.

Tools and Materials

Python – high level programming language, I knew Python from high school and the university course in the first year. This programming language was used to write the code for the implementation of the curvature calculation along the beam.

Bending beams - During the first semester of the second year, I studied the course Solid Mechanics, in which I studied the theory of small deformations and deflections in a static state under a point force or a divided force. The initial program of calculating the curvature of the finger according to a fixed point force was made according to the theory I learned.

Vibrations - The real force acting on the finger is time-dependent sinusoidal force. The beam affected by the force according to the theory of oscillations. Up to this moment I have managed to study only some of the material required for the purpose of writing a program that calculates the beam curvature also for a force that depends on time in a volatile state. In a state of oscillations the behavior of the object changes completely and becomes complicated to analyze.

Partial differential equations - During the first semester of the second year, I studied the Partial Differential Equations course. I learned types of equations and their solutions, these solutions and theories are necessary for finding the curve in a state of sinusoidal force on the beam (oscillations).

Research

The study I joined is led by Noam Nahum and is part of the robotic laboratory run by Avishai Sintov.

In the vibration manipulation research in which I participate, there is an attempt to find a way to enable in-hand manipulations using a cheap robotic hand.

With the help of an innovative method, a simple robotic hand can be used to move objects inside the hand. We use time-dependent force to create oscillations, which allows control within the grip.

For example, use finger force fluctuations to make a credit card slip for repositioning inside the hand.

The current hand in the research has a vibrating motor at the tip of the finger that allows for various oscillations of the held object. The different manipulations are forced by tuning the oscillations. Now the study focuses on moving a card, but different vibrations can create manipulations on others.

The goal is to provide the desired ability of in-hand control using a simple and inexpensive hand. Will allow the use of sensitive and within-grip manipulations in a wide range of areas. Improving manufacturing and performance for companies that needed in-hand manipulations but a sophisticated robotic hand was too expensive for them.

Need of research

There was a need to find the curve of the finger. Calculate the y position of each x of the finger and the tip of the finger in particular.

We assume a static state when constant force is acting, finding a curve of the beam/finger (Change in height depending on the location).

In the second stage, we refer to the exact situation, a state of oscillation in which the curve depends on time. A vibration motor causes a not constant force on the finger. The displacements are time-dependent and influenced by the force magnitude and frequency.

We had to know the curvature of the finger one each moment for analyzing.

(Vibration in detail in the [Future](#) section)

My work

To meet the need of the research, I modeled the finger as a harness beam for calculating the curvature of the finger.

I wrote a python program that finds the beam curvature. The program gets as input the force at the edge and a beam representation. The beam is constructed of different materials and cross-sectional areas that represent finger-like objects.

Using the theory of small deformations I learned in the solid mechanics course, the program finds the sheer force and the moment along the beam. Finally calculates the curve, and presents a graph of it.

Afterward, learn about the theory of vibration and develop the program to calculate the curvature of the beam as a function of time according to the edge force applied at different frequencies.

Future

Assuming a static state we created the infrastructure of a program which provides the ability to represent a beam with different materials and different cross-sectional areas, and has the computational power of calculating the moment, shear force, and the curve in a static state .

But the current situation is not static. The vibration motor exerts a Sinusoidal force on the finger which causes the oscillating system to change over time.

The program had to be improved and adapted to the existing situation. To calculate the moment, shear force, and the curve as a function of time in a non-static state of vibrations, we had to put in the calculations logic based on vibration theory.

I continued the program and built its foundation to adapt to the existing situation and address time-dependent forces as well as moment and shear force. I also learned about the theory of oscillations and solving partial differential equations that fit the problem.

Until now I have not completed the software in calculating the curve in the sine state of the oscillating system. The program should be continued in order to obtain the time-dependent information along the vibrations in order to perform analysis.

Summary

I enjoyed and learned a lot from participating in the research in the second semester.

During the first semester, I started a project and saw that I did not have the tools to advance it at the moment. This semester I joined the research and took part in the overall process in a side task I had to do. I was part of something innovative and significant that could greatly contribute to the advancement of robotics in various industries.

I had the opportunity to apply some of the topics I learned during Year A and Year B, including Python, solid mechanics, partial differential equations, and more. I have studied and researched in these areas and studied their connection to subjects and problems in the real world.

I want to thank the director of the laboratory, Avishai Sintov.

Thanks to Noam Nahum, the student I joined his research. Noam introduced me to the ideas, helped me with the program I was working on, and taught me about materials related to the study.

Also, thanks to Yair Shokef, the program director. For managing the program and helping in different subjects and activities.

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