École Polytechnique Fédérale de Lausanne

X-jaw

Master thesis

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Contents

1 Introduction

- Jaw is one of the most complex articulation in the human body with its 6 degrees of freedom and complex joint movement
- Chewing robot applications: food industry, medical field, dental field, etc.
- Chewing robot can be used to test food texture, dental implants, orthodontic devices, etc.
- Chewing robot can be used to study chewing disorders and develop treatments / also understand more about the human chewing process/development throughout life
- State of the art chewing robots
- Most of them are not able to mimic the human chewing process because not 6 dof / no saliva / no tongue / not able to apply the same forces as human
- Our aim is to create a chewing robot that can mimic the human chewing process as closely as possible

2 Methods

2.1 Required workspace and forces –> criteria for design

- max chewing force across literature
- max range of motion across literature

2.2 Mechanical design

- goal is to create a robotic jaw that can mimic the motion and force of human chewing
- 6dof stewart platform to be able to mimic the motion of the jaw
- linear actuators instead of rotary servo motors to have more efficient force transmission + simpler kinematics + more rigid structure
- choice of actuators based on the required force to mimic human chewing (speed less important as jaw can chew even if slow) + required length to reach the desired range of motion + feedback to control in position
- choosing the dimensions of the stewart platform based on the size of the actuators + working space of the robot
- choice of structure/material to hold upper jaw to be rigid enough to not deform under the forces applied by the actuators
- 3 axis load cells to measure the force applied by the jaw
- so far 3d printed teeth/jaw but to be changed in the future

2.3 Control

- electronics schematics ?
- inverse kinematics
- finding intial position of the actuators
- PID control for position
- state machine that will help for later coordination with other modules like tongue/saliva
- gui for user friendly use ?

2.4 human jaw motion with motion capture

- choice of placement of markers based on other papers
- describing the experiments we desired
- PCA for synergy control ?

3 Results

3.1 Mimicking human jaw motion

- human jaw motion from motion capture
- results of PCA on human jaw motion
- show graphs of human jaw motion vs robotic jaw motion
- show graphs of the force during chewing for human vs robot

3.2 chewing force

- max force that can be applied by the robot (both vertical and shear)
- show the force applied by the robot during chewing ?
- show the force applied by the human during chewing
- show the difference between the two

4 Discussion

4.1 Summary of findings

4.2 limitations

- So far very big and heavy robot due to steel plates and big actuator != human jaw
- 3D printed teeth/jaw not strong enough to withstand the forces applied by the actuators

4.3 Future work

- 3D printed jaw/teeth to be replaced by a more rigid material
- add a tongue module
- add a saliva module
- adapt state machine to coordinate the different modules
- add a camera to track the food

5 Conclusion

6 References