Simulating Safe Bite Transfer in Robot-Assisted Feeding with a Soft Head and Articulated Jaw

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1 Introduction

- Robot-assisted feeding requires close physical interaction with sensitive facial areas
- Safe bite transfer is challenging to study due to safety risks and lack of detailed physical human-robot interaction simulators [1,2]
- Need for simulation tools to evaluate safety before real-world trials

Goal: Develop a soft-body head model to enable evaluation of bite transfer safely in simulation, to personalise bite transfer parameters to the user for maximum comfort.

2 Head Modeling

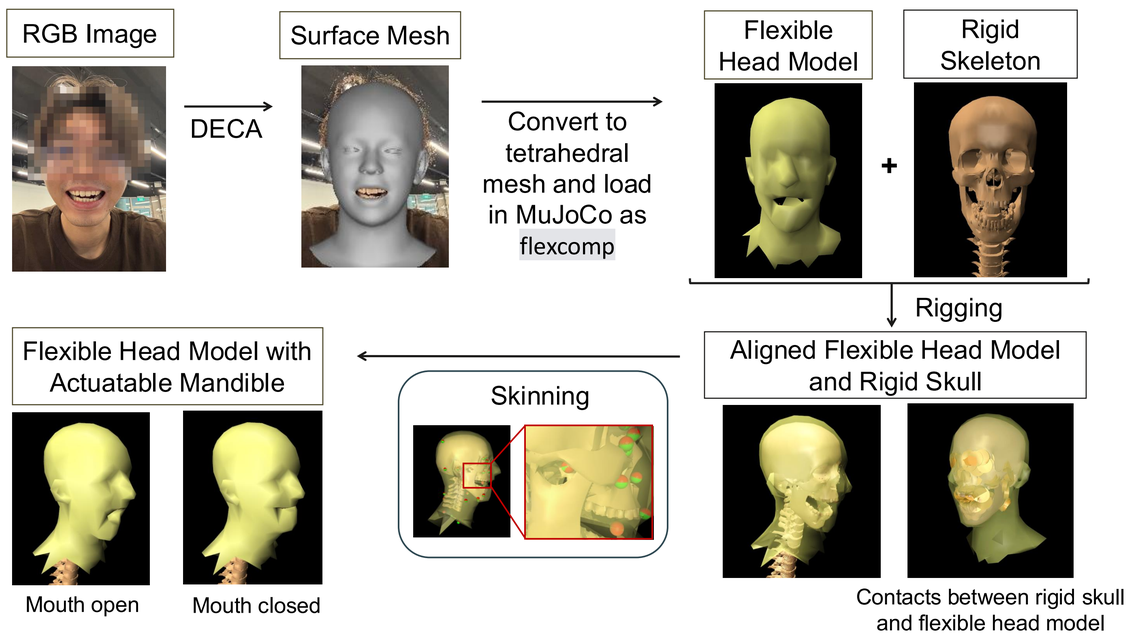
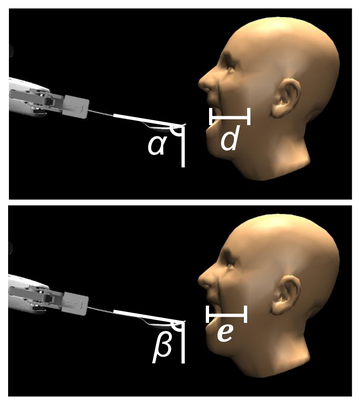


Figure 1: (Top) A flexible head model is generated from an RGB image. (Bottom) The flexible head model is combined with a rigid skeleton through rigging and skinning. Tendon elements connect the rigid and flexible models, based on sites created at contact points.

3 Bite Transfer Simulation



Phase	Parameter	Range	Increment
Entry	Entry Angle (α) Insertion Depth (*d*)	80° to 110° 50 mm to 100 mm	10° 10 mm
Exit	Exit Angle (β) Exit Depth(*e*)	80° to 120° 0 mm to 40 mm	10° 10 mm

Metrics

- **Peak Contact Force**: affects **instantaneous user comfort**, as high forces in short duration can lead to injury
- **Total Contact Force**: affects **overall comfort**, as prolonged low-level forces can still cause discomfort.

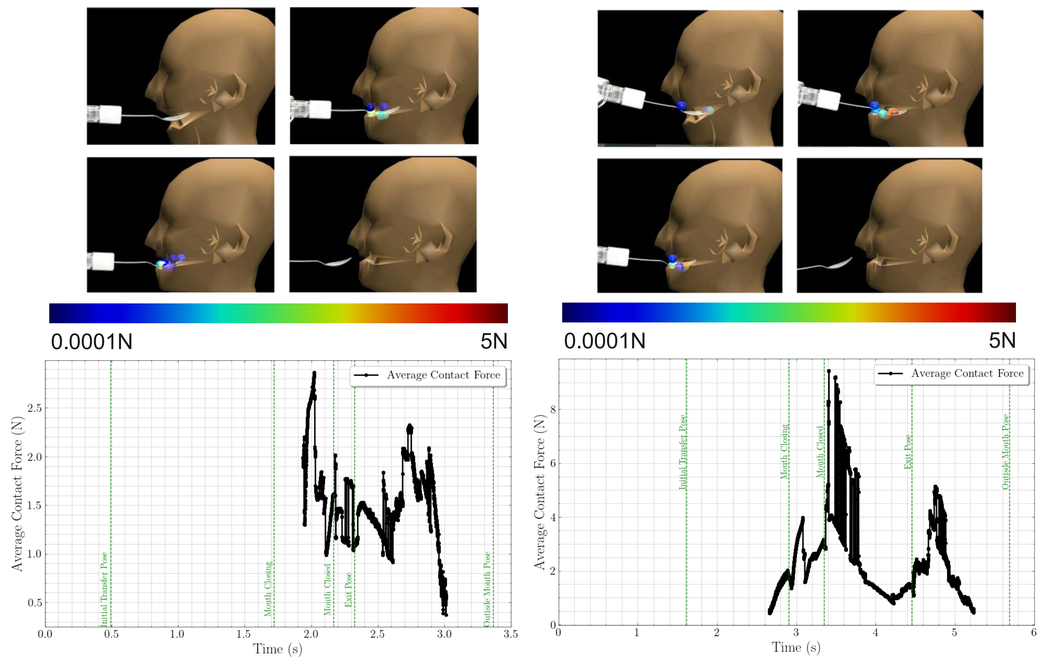


Figure 2: (Left) Optimal parameters (Right) Suboptimal parameters. (Top) Screen captures of the bite transfer process, contact forces visualized as coloured spheres. (Bottom) Contact forces over time.

4 Results

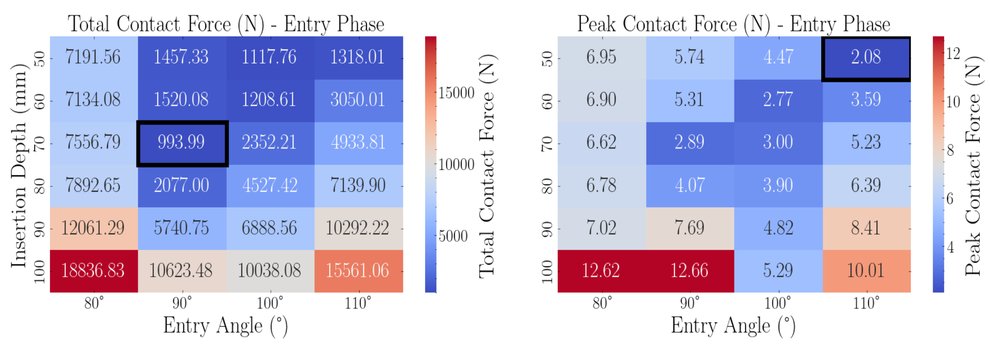


Figure 3: (Left) Total contact force and (Right) Peak contact force during entry phase

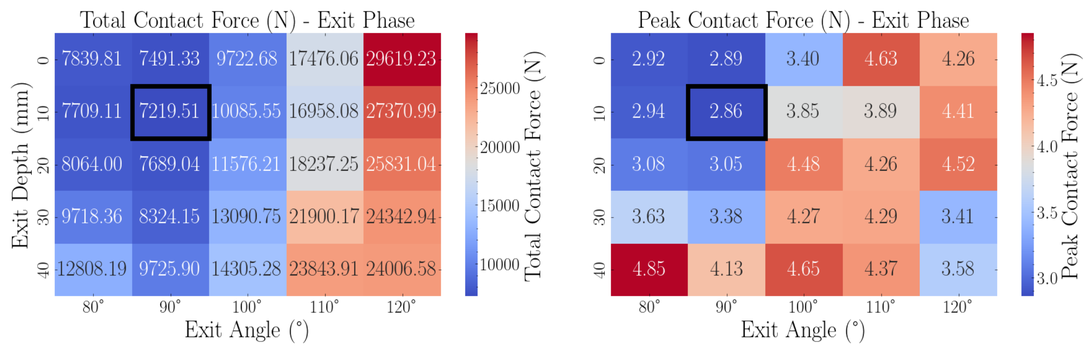


Figure 4: (Left) Total contact force and (Right) Peak contact force during exit phase

5 Conclusion & Future Work

- First integration of soft-body head modeling with realistic bite transfer simulation
- "Straight-in, straight-out" strategy is most comfortable
- Framework provides a safe, scalable tool for testing robot-assisted feeding strategies

Future work

- Add dynamic head and neck motion
- Model tongue, lips, and oral cavity, neck muscles
- Validate contact forces with real users

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[2] R. Ye, W. Xu, H. Fu, R. K. Jenamani, V. Nguyen, C. Lu, K. Dim-itropoulou, and T. Bhattacharjee, "Rcare world: A human-centric sim-ulation world for caregiving robots," in 2022 IEEE/RSJ InternationalConference on Intelligent Robots and Systems (IROS). IEEE, 2022, pp.33–40

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