Assessing Human Perceptual Acuity for Detecting Thyroid Nodules Through Palpation

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Introduction

Through the Science Influencers program, I worked in the INVENT Lab at Texas A&M University under Dr. Cynthia Hipwell and Dr. Anzu Kawazoe on research aimed at improving remote healthcare. About 20% of Americans live in rural areas, but only 10% of physicians practice there, limiting access to hands-on examinations like palpation for detecting thyroid nodules. Our lab is developing a remote palpation system where a nurse wearing a haptic sensing glove examines a patient while transmitting tactile information to a physician. Before building such a system, we need to understand the forces involved in palpation and how well the human hand detects lumps. My role spanned both directions, from characterizing palpation forces to running perceptual experiments and analyzing results.

Methods

Our first study characterized the forces physicians use during thyroid examinations (Chan et al., 2025). Through video analysis and ENT specialist interviews, we identified five primary palpation techniques. We measured normal and shear forces using an ATI Nano force sensor on Ecoflex silicone phantom skin samples. Both non-medical participants and trained physicians performed these motions on phantoms with and without embedded lumps. Our second study (Kawazoe et al., 2026) focused on two motions, Poke (pressing straight down) and Push & Pull (pressing down with lateral movement), to test lump detection and size discrimination. I helped conduct two experiments using phantoms with hemispherical lumps from 5 to 30 mm at shallow (11 mm) and deep (20 mm) depths. In Experiment 1, 12 participants completed 60 trials identifying which of two samples contained a lump. In Experiment 2, 10 participants completed 180 trials comparing lumps against a 20 mm reference to measure discrimination thresholds. I ran participants through the protocol, managed the PsychoPy software, and processed data for analysis.

Results

The force study revealed physicians apply up to 6 N of normal force and 3 N of shear force, and that these must be measured independently since their relationship varies across motions (Chan et al., 2025). In the perceptual study, participants achieved near perfect accuracy (95 to 100%) across all lump sizes. A significant interaction between motion and depth emerged at 5 mm, where Push & Pull outperformed Poke in the deep condition. Participants rated Poke as significantly more difficult ($p = 0.010$), and deeper lumps caused more exhaustion ($p = 0.027$). For size discrimination, Push & Pull yielded significantly smaller just noticeable differences (1.64 mm vs. 3.10 mm), meaning finer size differences were detectable with lateral motion (Kawazoe et al., 2026).

Conclusion

This experience taught me to design psychophysical experiments, work with participants under IRB protocols, characterize haptic forces, and analyze perceptual data. Our findings establish that remote palpation systems must capture normal and shear forces independently and deliver both normal and lateral force feedback. This research contributed to two publications and provides a baseline for designing haptic sensing technology that can expand access to accurate physical examinations through telemedicine.

References

Chan, A., Kawazoe, A., Kim, N., Friesen, R., Ferris, T., Quek, F., & Hipwell, C. (2025). Characterization of medical neck palpation to inform design of haptic palpation sensors. Sensors, 25, 2159.

Kawazoe, A., Kim, N., Ferris, T.K., Friesen, R.F., & Hipwell, M.C. (2026). Effects of palpation motion on human perceptual acuity in lump detection and size discrimination. 2026 IEEE Haptic Symposium.