Final Project:

How can Soft Haptics Impact the Future of Work?

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Industrial Revolutions and the Future of Work

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Introduction

The Fourth Industrial Revolution is redefining how we work. In the coming decades, advancements in physical, digital, and biological technologies will impact the nature of our global economy, politics, society, and even our individual identities, moralities, and ethics.[1] In the field of robotics, such trend is manifested in rising technology known as Soft Haptics. As a mix of robotics and materials science, it will create multi-purpose smart programmable materials specifically for interactions that involves the sense of touch. Soft Haptics will thus promote human interaction, critical thinking, and creativity in workforce.[2]

Defining Soft Haptics

Soft Haptics is a loosely defined, relatively new term, stemming from Haptics, the science of sensing and manipulation through touch.[3] It deals with haptics not from a traditional approach involving rigid hardware, but from creating and controlling soft materials. For illustration, imagine a rigid bare-skeleton T-800 android in Terminator being upgraded into human-like but shape-shifting T-1000 from *Terminator 2: Judgement Day*.[4] The character is described as a conglomeration of nano-robots that are electromagnetically powered and self-programmed to achieve group-coordinated movements that resembles dynamic materials (more in the annotation).[5] Microbots from Big Hero 6 displays similar technology, although the robots here are bigger and visible to naked eyes..[6] The technology can also manifest itself in form of a shape-shifting room. The Holodeck from the Star Trek TV series and the Veldt

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1. Klaus Schwab, *The fourth industrial revolution* (Currency, 2017).

2. World Economic Forum, "The future of jobs report 2018" (World Economic Forum Geneva, 2018).

3. Georgios Karafotias et al., "Towards a realistic haptic-based dental simulation," in *2017 IEEE International Symposium on Haptic, Audio and Visual Environments and Games (HAVE)* (IEEE, 2017), 1–6.

4. James 1954- Cameron et al., *Terminator 2 [videorecording] : judgment day* [in eng], Santa Monica, Calif., 2003.

5. Ibid.

6. Chris 1971- Williams et al., *Big Hero 6 [videorecording]* [in eng, fre, spa], California, 2015.

from Ray Bradbury's story depicts a virtual room that can simulate real environments, not only visible, but also touchable.[7][8]

Note that soft haptics is not synonymous to soft robotics. For instance, Baymax from Big Hero 6, inspired by Atkeson's soft robotics research, is not strictly Soft Haptics robot, as it cannot change it's physical properties dynamically in a controlled manner.[9] In the movie's case, the protagonist in the movie had to manually put armors on Baymax to make it hard and strong.[10]

Soft Haptics in Research

Present-day electromagnet-based haptic technology lack the ability to make such a versatile system, as mentioned by Biswas and Cruz.[11][12] Developments in emerging materials can address such issues, complementing cutting-edge audio and visual tech innovations. These materials include "... organic and inorganic soft materials, nano-materials, functional fibers or textiles, liquid alloys, and composite materials".[13]

Ball highlights highlights high profile Soft Haptics-based research on programmable matter from 1991 to 2014, starting from the the conceptualization of Claytronics.[14][15] He

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7. Gene Roddenberry et al., *Star trek, the next generation. Season 1 [videorecording]* [in eng], United States, 2002.

8. Ray Bradbury, *The veldt* (Dramatic Publishing, 1972).

9. *Big Hero 6: Let's Build Baymax*, http://www.cs.cmu.edu/~cga/bighero6/.

10. Ibid.

11. Shantonu Biswas and Yon Visell, "Emerging material technologies for haptics," *Advanced Materials Technologies* 4, no. 4 (2019): 1900042.

12. Manuel Cruz et al., "Applications of smart materials to haptics," *IEEE Transactions on Haptics* 11, no. 1 (2018): 2–4.

13. Biswas and Visell, "Emerging material technologies for haptics."

14. P. Ball, "Infinitely malleable materials," *IEEE Spectrum* 51, no. 6 (June 2014): 40–44, doi:10.1109/MSPEC.2014.6821618.

15. Tommaso Toffoli and Norman Margolus, "Programmable matter: concepts and realization," *Physica. D, Nonlinear phenomena* 47, nos. 1-2 (1991): 263–272.

also outlines the technology's ethical and societal consequences, and refer to related ancient and recent fictional works, making it ideal to shed light on possible impact on the future of work.[16] There are other research similar to this effort, such as those done by Hall and Drexler in the late 1980s.[17][18]

Since then, IEEE Spectrum has since not updated on the effort.[19] Presumably, the technology is impractical due to high level of energy required for electromagnetically control it.[20] Biswas, as an alternative, mentions several potential materials under development including "... organic and inorganic soft materials, nano-materials, functional fibers or textiles, liquid alloys, and composite materials".[21] Evidently, Soft Haptics is becoming more interdisciplinary, involving material sciences and engineering, mechanical engineering, electrical engineering, and computer science. In essence, it is an evolving field of robotics.

Using such emerging materials, research is being conducted with specific applications in mind. Ho has created bio-inspired artificial skins made of soft materials that can be put on soft robotic arms to hold and put contact lens on human eyes, or even pick up tofu.[22] Wurdemann is developing robotic hands that can sense soft surfaces.[23] Okamura has created artificial skin that can simulate hardened tumors.[24] These research indicate that Soft Haptics

16. Ball, "Infinitely malleable materials."

17. J. Storrs Hall, "Utility fog: A universal physical substance," in *Vision 21: Interdisciplinary Science and Engineering in the Era of Cyberspace* (December 1993), 115–126.

18. K Eric Drexler, *Engines of creation* (Anchor, 1986).

19. Ball, "Infinitely malleable materials."

20. Ibid.

21. Biswas and Visell, "Emerging material technologies for haptics."

22. P. V. Nguyen and V. A. Ho, "Grasping Interface With Wet Adhesion and Patterned Morphology: Case of Thin Shell," *IEEE Robotics and Automation Letters* 4, no. 2 (April 2019): 792–799, doi:10.1109/LRA.2019.2893401.

23. *bio-inspired, soft and stiffness-controllable robotics*, https://helge-wurdemann.com/softhapticslab/soft-robotics/.

24. *College of Engineering Spring 2019 Distinguished Lecture*, https://www.youtube.com/watch?v=qpw4TU6nVIs.

has immediate applications in healthcare and rehabilitation, and high fidelity remote working when combined with high broadband 5G Internet technologies.

Soft Haptics in Industry

Current market analyses already show that Haptics industry, a superset of Soft Haptics, will grow from "...$9.50 billion in 2017 and is expected to reach $42.36 billion by 2026 ", driven largely in North America, Europe, and Asia.[25] Presently, top tech and research institutions are opening a few positions related to haptics. They are largely confined to the field of research and development, requiring at least a bachelors degree in robotics-related fields and a few years of industry experience or masters degree. Some of them require PhD degrees as well. Apple posted four haptics engineering jobs in the second quarter of this year, as well as as three more jobs with the keyword "haptics" included in their job descriptions.[26] Facebook is currently searching for a researcher in haptics, as well as 52 more jobs with haptics in their description.[27] Microsoft is searching for four haptics-related jobs.[28] Max Planck Institute, one of the top research institutions in Europe, is actively accepting various research and academic positions within a department that is entirely dedicated to haptics.[29]

Future of Work

With the arrival of Soft Haptics technology, tasks at work will no longer be based increasingly on human interaction, critical thinking, and creativity. Although there are other

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25. *Haptics Technology - Global Market Outlook (2017-2026)*, https://www.strategymrc.com/report/haptics-technology-market/description.

26. *Apple Haptics Job — Glassdoor*, https://www.glassdoor.com/Jobs/Apple-haptics-Jobs-EI_IE1138.0,5_KO6,13.htm.

27. *Facebook Haptics Job — Glassdoor*, https://www.glassdoor.com/Jobs/Facebook-haptics-Jobs-EI_IE40772.0,8_KO9,16.htm.

28. *Microsoft Haptics Job — Glassdoor*, https://www.glassdoor.com/Jobs/Microsoft-haptic-Jobs-EI_IE1651.0,9_KO10,16.htm.

29. *Career — Haptic Intelligence - Max Planck Institute for Intelligent Systems*, https://hi.is.mpg.de/jobs.

skills that would also be in high demand, as shown in Figure 1, the three aspects do cover with these to some extent.[30] It is worth noting that this is similar to how more established 4IR technologies such as VR/AR and AI have been impacting work[31] .[32]

Today, 2018	Trending, 2022	Declining, 2022
Analytical thinking and innovation	Analytical thinking and innovation	Manual dexterity, endurance and precision
Complex problem-solving	Active learning and learning strategies	Memory, verbal, auditory and spatial abilities
Critical thinking and analysis	Creativity, originality and initiative	Management of financial, material resources
Active learning and learning strategies	Technology design and programming	Technology installation and maintenance
Creativity, originality and initiative	Critical thinking and analysis	Reading, writing, math and active listening
Attention to detail, trustworthiness	Complex problem-solving	Management of personnel
Emotional intelligence	Leadership and social influence	Quality control and safety awareness
Reasoning, problem-solving and ideation	Emotional intelligence	Coordination and time management
Leadership and social influence	Reasoning, problem-solving and ideation	Visual, auditory and speech abilities
Coordination and time management	Systems analysis and evaluation	Technology use, monitoring and control

Figure 1. Comparing skills demand, 2018 vs. 2022, top ten[33]

Human Interaction

Soft Haptics will reduce tasks in work that manages logistics in moving resources, including people. For example, in health care, Soft Haptics can lead to shapeshifting physical medical models for medical training simulation, particularly for palpation and surgeries. Students oftentimes use manikins or patients for training, which respectively requires procurement and patient availability.[34] Soft Haptics technology could be utilized to create all-purpose models that could be programmed to re-shape into configurations of infinite combinations, reducing these need. Instructors and staffs that have traditionally spent time on procuring resources could use these time on more individualized student teaching, which requires skills in human interaction such as emotional intelligence.

Devices in the more distant future could shapeshift into more diverse objects, making B2B interactions easier. The devices can be likened to a smartphone displaying Amazon's

30. Forum, "The future of jobs report 2018."

31. Joseph E Aoun, *Robot-proof: higher education in the age of artificial intelligence* (MIT press, 2017).

32. Schwab, *The fourth industrial revolution*.

34. Karafotias et al., "Towards a realistic haptic-based dental simulation."

products, except it deforms into the product that customers can touch. Even without Soft Haptics, companies such as Tanvas is already selling tablets that can simulate surface textures such as fabrics (i.e. for clothes shopping). By digitizing such realistic preview of products, businesses can shop for materials without physically traveling to suppliers to inspect. Furthermore, companies can send real-life product prototypes between its contractors to accelerate manufacturing processes, a phenomenon that parallels how additive manufacturing revolutionized production processes.[35] These advancements will dramatically reduce the need for physical transportation of resources and people, freeing up time for further product development, accelerating competition between businesses to come up with creative, critically thought business ideas, most likely by encouraging employees to acquire multicultural competency to work with diverse colleagues and stakeholders.

The same can be said with B2C interactions. Such devices could eventually shapeshift into people as well, as if an individual can effectively simulate in-person interaction remotely. This is known as telepresence, where in practice, individuals can be anywhere in the world using this device, and still be safe from physical harm that the device filters out. In telemedicine, depending on how realistic it is, doctors could diagnose patients that are remotely presenting themselves. Doctors, combined with those in related jobs such as reception, medical aid, and nursing can reach out to not only patients from their own community but also from any other parts of the world, given the technological infrastructure. In the emerging telemedicine industry, patients would more likely choose to use medical service with quality human interaction, thereby incentivizing employees to have qualities such as being friendly, sociable, and helpful.

Similar predictions have been made on related technologies in the context of virtual and augmented reality. VR and AR headsets is seen as a way to obtain immediate information to individuals to make informed decisions for work activities. Such statement translates well in tactile realm about making human interaction more common in work.[36] In addition,

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35. *Create Anything You Want With Programmable Matter*, https://www.youtube.com/watch?v=JN7BUKbOOIA.

36. Schwab, *The fourth industrial revolution*.

there could be improved capacity to perform tasks that produce goods and services with visual aids for manufacturing, healthcare/surgery and service industry..[37] The effects of these technology to the future of work seems to be highly applicable for soft haptics as the main difference between them is the matter of which human sense they are trying to enhance: vision for VR/AR and the sense of touch for Soft Haptics.

Critical Thinking

While the increase of human interaction seems to be to he positive aspect in the future of work, there will be more need for critical thinking and creativity in order to address potential issues created by Soft Haptics. Taking the case of virtual reality, there has been concerns of users getting traumatized from negative immersive experiences, as well as getting addicted and escaping from reality.[38] These seem unavoidable if VR/AR succeeds in creating a new segment in the entertainment industry.[39] Such issues would most likely require solutions not only from specialists from traditional fields, but also content creators that can understand the complexity of such issue, especially by refraining from a techno optimist approach to solve it. For example, just adding "please take a 15 min rest" notification into VR games would not stop user addiction. There could be consideration of a larger system's role in social issues and how that can be addressed. Needless to say this requires critical thinking to assess issues in interdisciplinary manner.

Although Soft Haptics will certainly accelerated product development and reduce duration of design-to-manufacturing cycle, this will consequently accelerate redundancy of employees skills. It is therefore in employee's best interest to have the critical thinking to apply their existing skills for new tasks and work environments.

Similar to the with the VR/AR example with regard to entertainment, other fields might also have to address system-level innovation. For instance, education systems could

37. Schwab, *The fourth industrial revolution*.

38. Ibid.

39. Ibid.

be innovated to incorporate Soft Haptics. This is not limited to K-12 and higher education, but more importantly to lifelong learning under a broader scope. This could involve diverse stakeholders such as haptic device and content engineers, educators, designers, policy makers, business leaders, and tax payers. As another example, a mixed group of specialists should set standardization and restrictions to go together with Soft Haptics' democratizing power of creation and manufacturing. This could involve discussions on to what extent should the technology be open source and not be proprietary to large powerful companies and government entities. Haptics' application, once advanced enough, could include adult entertainment devices and weapons, and leaving such powers to a large population could have detrimental effects. Even for less immediately harmful applications, there will be questions on how privacy can be ensured for user data recorded by haptic devices. Such issues may have to be addressed by lawyers, ethics practitioners, engineers, among others, again highlighting the need for critical thinking in addressing such complex issues.

Creativity

Soft Haptics could eventually be used in larger systems such as virtual and augmented reality rooms. Michael Abrash, Facebook's top virtual reality researcher, ultimately aims to create virtual but nonetheless tangible office spaces that one can work with remote colleagues independent of their locations.[40] Tourism industry could simulate vacations on these rooms, equivalent to services provided by the Holodeck from Star Trek or the Veldt conceived by Ray Bradbury. Multinational companies such as ANA, a Japanese airline company, in collaboration with XPRIZE, is spear heading efforts in avatar creation since 2018, utilizing not just VR/AR, but more importantly haptics.[41] ANA's CEO, during it's tech venture

40. *Oculus Connect time machine: How well has Michael Abrash predicted VR's future?*, https://venturebeat.com/2019/09/21/oculus-connect-time-machine-how-well-has-michael-abrash-predicted-vrs-future/.

41. *ANA AVATAR— Beyond All. Connecting people limitlessly for a better world*, https://ana-avatar.com/english.html.

launch ceremony of avatar-in, pledged to make complete telepresence, including complete simulation of sense of touch, among other senses, by 2050.[42]

Such innovations can create a new medium of expression for human creativity. Although VR/AR rooms can be used to model existing environments, it has unexplored potential in creating worlds that are difficult or impossible to achieve in real life. This is already demonstrated in the wide genre of video games and movies. Needless to say, these media exemplifies the crucial role creativity plays in achieving innovative content creation. Although these technology would likely make certain tasks redundant, such as tour guiding and travel planning, as in line with previous arguments, it would most definitely leave these employees with need to reskill themselves to perform creativity-oriented task like these.

Conclusion: So What

Soft Haptics is in its infancy both in academia and research. Nonetheless, its impact on the future of work suggest that we should start discussing how to promote emotionally intelligent human interaction, critical thinking, and creativity in work. This is not to say that Soft Haptics will bring entirely positive outcomes on work, as not equipping workers with these skills could lead to detrimental consequences such as increased inequality. However, it is certainly the case that the nature of work in the future will demand more abstract and intangible human skills that are difficult to learn in traditional education system. Therefore, society should work toward innovating infrastructure for such purposes, informing individuals to take their own initiatives towards finding resources to reskill themselves as well.

Word count: 2203

42. *(English translation) "ANA Avatar" Changes the Future Keynote Speech by ANA Holdings CEO Katanozaka*, https://avatarin.com/report/877/.

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