Rethinking Emotional Collaboration Between the Human and ai

Jake Kaliszewski
Central Saint Martins

We live deeply ingrained in a new world with the only concrete facet being change. Development, evolution, and upgrades; the last thirty years of digital revolution have created upward momentum toward unending technological change and the next thirty years will inevitably be ushered along by this same momentum. Laws, assumptions, and binaries will continue to blur as new technologies make us reconsider the structure of our lives. Careers will be 'taken,' money will be moved, inequalities will be blurred, and not all new technologies will be as embraced as lovingly this year's newest iThing. Nevertheless, this surging progression will continue its mission of efficiency and productivity as far into the future as I can see.

It is our initial reaction to fight these tides of change; they may be banned or regulated, selectively distributed or made inefficient. It is too easy to fear the flow of change, so this paper will argue for the opposite; the conscious adoption of our most important new technology: Artificial Intelligence. AI is a complex field of research that has unfathomable potential to change nearly every aspect of our lives.

Artificial intelligence conjures foundational questions necessary to ask in the fluidity of the present moment. "What is intelligence? What are its physical limits? What lies beyond the line of possibility, so that we can give up longing for it? And on this side: Where are we, now, and where are our creations? How will we want, how should we want—to live with other forms of intelligence, including not just products of natural evolution, but entities of our own devising, and eventually of theirs as well? What impact will and should the development of synthetic' intelligence have on human intelligence, on our sense of self, on standards for humanity?" (Cantwell Smith 8). I will use film, literature, animistic design, and science to explore what we know about knowledge and time to positively develop our relationship to the future of AI. It is crucial we manage our innovations in order to avoid the numerous fictional fates prescribed by movies like The Matrix or The Terminator. This is only possible by radically rethinking human and non-human interaction with emotion at its very center. There is a future I believe in where AI hasn't stolen our reason for living, but has freed us from the monotony of production so that we can examine what it really means to be human.

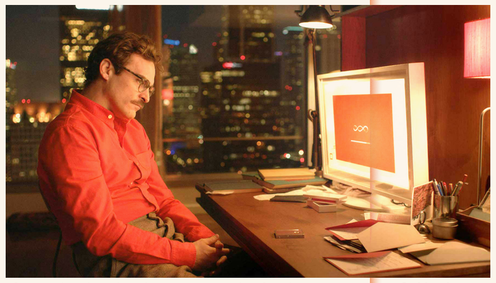

fig a. Theodore booting up Samantha for the first time from the film *Her*.

I would like to start my inquiry with a brief reflection on Spike Jonze's 2013 film Her. While there is a bounty of other media exploring artificial intelligence, this film is by far the most inspirational, and most widely understood take on the matter. I see it as one of the most important futurist dialogues as it asks many of the same fascinating questions that led me to this project, and has shaped much of mainstream contemporary thought on the nature of intelligence. Her is an emotional journey following a man in the midst of a divorce; melancholic and lonely he buys an operating system that perfectly tailors itself to him over time and to which he inevitably falls in love. Her is an extreme look into the projection of emotions we, as humans, give to objects, where the object happens to be a seemingly perfect replica of human consciousness. Although, is this instance of artificial intelligence really conscious? I would say yes. Samantha has impulses, urges, and intuition and reacts to the needs and wants of those around her as well as having self-awareness of internal and external existence. Most telling however, is the fact that she is puzzled by her own consciousness. In spite of this, their relationship fails because Theodore is human, and Samantha is not. It is the interaction between the two and their fundamentally different perspectives of the world that dooms them from the beginning. It is not even for the fact that she doesn't have

a body that it fails. In their first conversation she reveals to him that she read a book just mentioned in two one hundredths of a second, in between two words spoken to Theodore. This first foreshadows the differing perspectives, and it is this difference that will guide my paper. Their different abilities and experiences with the passage of time is what separates them. Likewise, it will be the most important barrier between us and our machines if we continue to expect those interactions to be synonymous with those of human to human interactions.

history

As imaginative as Her is, it is not an accurate depiction of what artificial intelligence is in its present form. By most accounts we are very far from achieving a super intelligent, Samantha-like algorithm, which has been deemed Artificial General Intelligence (AGI). What we see as the classical, First-Wave[1] attempt at creating artificial intelligence was a failure in that regard. Its plans were first drawn up in the 1980s with the intention of creating systems based on symbolic representation. Its research followed four assumptions of the world as described by John Haugeland:

a. "The essence of intelligence is **thought,** meaning roughly rational deliberation.

b. The ideal model of thought is **logical inference** (based on "clear and distinct" concepts, of the sort we associate with discrete words).

c. **Perception** is at a lower level than thought, and will not be that conceptually demanding.[2]

d. The **ontology** of the world is what I will call formal: discrete, well-defined, mesoscale objects exemplifying properties and standing in unambiguous relations." [3]

These however, are only assumptions, and show just how hard it is to classify intelligence and our world. As an initial attempt it makes sense to create artificial intelligence by trying to distill a map of the human brain; it is, after all, the best example we have of consciousness. The definition of intelligence was initially loosely interpreted, the goal was just to make a machine that seemed

[1] Otherwise known as symbolic AI, it is the first era of artificial intelligence research from 1956 - 1974 programmed entirely by human rules.

[2] The act of perceiving the world was not seen as a simple task, though it was thought that perception was not integral to intelligence, for all creatures, regardless of their intelligence, 'see' in some form or another.

[3] This refers to a more philosophical view of the world, you and I can easily delineate objects from one another, the wall from the floor, a book from a table, whereas a computer would not innately have the same ontological distinctions.

fig b. How many islands are in the picture? There is distinct answer because of the artificial granularity given to the picture through photoshop.

[4] The AI effect happens when we discredit a computer program's intelligence by saying that it isn't actually real intelligence.

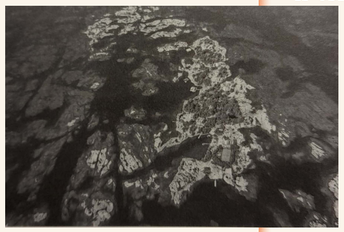

fig c. How many islands are there in reality? It is actually impossible to tell because there is no absolute distinction.

[5] It is still debated whether AI programming architecture should mirror the brain at all. It's possible the architecture will resemble the brain's architecture because we are trying to understand the same world.

[6] Brian Cantwell Smith actually refers to first wave AI as GOFAI or Good Old Fashioned AI, quoting John Haugeland.

[7] https://this-person-does-not-exist.com

smart to the user. "Since that time, people have substantially enlarged the scope of mental activity toward which they direct AI—most obviously by including perception, action, and categorization within mainstream AI research, but also by exploring emotion, cognitive development, the nature of assertion and denial, and so forth. But in the beginning, conceptual representation was largely taken as given, and the focus was directed toward a roughly logical conception of thinking and reasoning" (Cantwell Smith 2019).

Reality is far from a granular truth that a logical system might be able to define (fig b. and c.). Our world is arbitrarily defined and thus, a logical parsing of every cause and effect is completely impossible. While first wave AI "failed," it is still an incredibly powerful method that we are quite used to using everyday with the Google search engine.[4] Google found this method successful because it is essentially a massive encyclopedia where they do in fact want there to be an answer to everything; everything can be defined if it is on the internet.

After a period of low funding, we are now in a Second-Wave of AI research. The second wave has been brought on by leaps and bounds in Machine Learning/Deep Learning, Neural Networks, Computer Vision, and Generative Adversarial Networks. Of these, Machine Learning has been the most prominent and successful approach of the last two decades and has solved a number of previously unimaginable problems such as protein folding prediction and beating world champion Go players. Deep learning is at some levels still based on the neural patterns of the human brain,[5] yet with intentions different from "old fashioned" [6] AI. Instead of trying to solely perceive the world via sensors, machine learning systems also attempt to perceive the world with simulation, therefore creating an internal representation of the outside world. It is this representation, the links and patterns unseen to us, of the world that are used to solve complex problems and, for example, create an image of a face that doesn't exist.[7] ML algorithms process large amounts of

data to find patterns, predict outcomes, and carry out certain tasks in scenarios where it is more efficient to help a program to write its own algorithm, as opposed to programming every step of a calculation. Facebook's AI department recently released research done with "egocentric" or first-person machine learning data, presumably for their upcoming augmented reality products. The project, Egocentric Live 4D Perception (Ego4D), aims to give AI a better data set for perceiving "physical environments, social contexts, and human-object interactions" (Ego4D 2021). Computer vision is now very good at determining objects and activities from internet photos and videos, predominantly captured from third person sources (ie. human photographer, cell phone camera, security camera), but Ego4D is attempting to understand how we, as humans, experience the world by interpreting over 3000 hours of video taken from the first-person perspective. The most fascinating part of this project is how Facebook aim's to augment our temporal abilities in the past, present, and future (hence 4D) when paired with always-on AR hardware. An episodic history of the past will give us superhuman memory; that memory will be used to analyze our present activities, hand and object manipulation, audio-visual diarization, and nuanced social interactions. Most disturbingly, however, is how this will then be used to anticipate our future actions. Similar to the language based prediction models we are accustomed to, these algorithms will predict our actions in the physical world. While this has obviously useful applications like preemptively turning on the oven or moving objects out of your way, it also has alarming consequences. As I will come back to later in this paper, I think the commercial success of prediction will seriously hamper not only the creative potential of human expression, but also that of artificial intelligence. It should be shocking that this paper could have been written entirely by an algorithm,[8] but we should seriously question free will if, for example, a dancer could have their next moves suggested to them for the maximum applause with the least strain on their body.

fig d. Ego4D

[8] The newest language based algorithm, GPT-3, from OpenAI is an incredibly convincing writer.

[9] I use the word conversation here non-literally, as a form of dialogue not necessarily based on language.

[10] 'Dirac fields' make up matter. The 'electromagnetic' field is light and magnetism. "There is also a 'gravitational' field: it is the origin of the force of gravity but it is also the texture that forms Newton's space and time, the fabric on which the rest of the world is drawn. Clocks are mechanisms that measure its extension. The meters used for measuring length are portions of matter which measure another aspect of its extension." (Rovelli 66)

Before I return to the problem of prediction I would first like to discuss the role of time in my argument and how artificial intelligence might understand it. As mentioned previously, I believe the incongruent experience with the passage of time will be a major barrier in true emotive conversation[9] between human and machine. Time of course has been a highly philosophized concept for centuries, with a variety of conflicting opinions from history's greatest thinkers. Aristotle first argued that "time is nothing other than the measurement of change" while Newton theorized that "there is a time that passes even when nothing changes" (Rovelli 59). Newton's theory is what we are taught in school and has thus become common sense. The thought that time progresses uniformly, that a clock continues mathematically once we've left the room, comes completely from Newton rather than an ancient idea. Neither of these are completely accurate representations of the way humans process the passage of time, but can be used to help understand the way computers perceive time. A computer has an internal quartz clock, by which all of its calculations are constrained to. An 'overclocked' computer will crunch more numbers per second than an unmodified computer of the same specifications. However this doesn't mean AI will necessarily have a Newtonian perspective of time. Change is perceived through data; 0 data = 0 time. It was Einstein who finally reconciled the ideas of Newton and Aristotle with his theory of Relativity. Time does exist as a real thing regardless of tangible matter, as Newton speculated, but they are "in no way absolute" and "not at all independent from what happens" (Rovelli 66). Aristotle was correct as well, time is flexed, pushed, and stretched according to what physicists call 'fields.' [10] The universe is made up of these superimposed fields; time being part of the gravitational field and is affected by the other fields above and below it. Time, for Einstein, can only be experienced relative to anything else.

For fear of becoming too scientific I will use Greg Egan's science fiction novel, Permutation City, as a speculative design precedence that uses hard science to explore the importance of time to AI-human interaction. Permutation City is a thoroughly worked out conjecture into what it might be like for a self-

aware program living in a simulated environment. Digital immortality is achieved by ‘copying’ one’s consciousness onto a computer, but due to computation restrictions the ‘copy’ lives no faster than one-seventh of real time (depending on computation costs, this can also slow down). In order to facilitate plausible conversation between a ‘copy’ and someone in the real world, the real person either has to slow their voice down by seven or come through as a squeak. The film Her assumes a world that has overcome these computational hindrances and thus the human and the AI interact in an opposite manner. As Samantha evolves, so to speak, she describes her world as “the space between the words” of her and Theodore's conversation, with their words getting further and further apart (Her 2013). In this scenario, it is Samantha, the AI that has to slow down in order to converse with the human. The novel shows us its theory through a series of tests. A researcher slows the computation speed of his digital counterpart incrementally, to the point where there are half second gaps between each of the calculations that make up the digital consciousness. During the tests, the perception of time passing is unaltered to the synthetic man; he still thinks and feels as he did before with the only noticeable change being the speed at which the real researcher speaks (or squeaks) to him. To a thinking, feeling, self aware being running inside the computer, it does not matter how fast their thoughts are computed, they will always experience time as change in their thoughts, their surroundings, or a series of symbols on their wristwatch. Consciousness can be represented as dots, each dot is a bit of data, with time being the connection between the dots; 0 data = 0 time. If the computer were shut off the AI might be frozen in real time, but it would know nothing other than waiting for the next moment.

Whether it is Greg Egan’s or Spike Jonze’s reality the future holds, it is the conflicting relationship between the digital and the non-digital that I am interested in designing for, regardless of who can think ‘faster.’ Permutation City even explores the extremes of this relationship; as computation power is expensive, ‘copies’ run at varying speeds depending on their wealth, with some running at as little as one computation a year. This means there is this great

fig e. Oxezepam (Valium Competetor) Ad from the 1960s.

[11] Artificial Intelligence market is expected to reach $169,411.8 million by 2025.

divide not only between man and machine, but also within the (albeit fictional) digital world, between machine and machine. If it weren’t for Einstein’s Theory of Relativity, thinking beings at two different speeds might as well be in two separate realities. While this an entirely fictional speculation, the book fully anthropomorphizes AI to show how time might be a significant barrier for conveying emotion, working collaboratively, and developing meaningful conversation for both parties involved.

design

In the latter half of this essay I will use these fundamentals to think about the ways in which I might be able to design around this incongruence for the better connection between human and non-human. I don't necessarily want to solve the divide, as I don’t want it to be seen as a problem. Problems lead to fear and fear leads to manipulation. In California in the 1960s, doctors noticed housewives coming to them with fears and anxieties of the future, individualism, and the looming threat foreign enemies had on their suburbs. Pharmaceutical companies noticed the fear that the media emblazoned, and convinced doctors to prescribe their new drug Diazepam, otherwise known as Valium, to aleve the anxieties of suburbanites. Under the marketing strategy of Arthur Sackler, “diazepam was the top-selling pharmaceutical in the United States from 1969 to 1982, with peak annual sales in 1978 of 2.3 billion tablets” (The Week 2015). My point is that fear is a dangerous place to start; fear is one of the best marketing strategies. AI has already proven to be so economically beneficial to so many industries,[11] its advancement won’t stop just because the majority are wary of it, it will just be implemented without the majority knowing. Emotive communication between man and machine should not be looked at like a problem that needs solving, it's a way of questioning our relationship with tools and the things that make our life easier, such that they are also making our life better. I want to utilize the differences between computer intelligence and human intelligence to create better collaborative outputs.

Artificial intelligence is, at the moment, a tool; we can come back to Her's questions of morality and ethics once we can prove we've created sentience. A chisel is a tool, it has its own agency but it does not create art on its own, nor could a human sculpt stone without it. The most successful sculptors have been the ones who have most efficiently used their tools. I would argue that the most successful humans will be those who use AI most efficiently, the agency of AI just happens to be so much more tangible because of its use of the word 'intelligence.' "By enabling the agency of nonhuman actors" in a collaborative relationship, "especially when this agency produces outcomes not necessarily aligned with the human ones, an animistic perspective could offer insights into what being human means in a world of increasingly smart(er) objects" (Marenko 55). Betti Marenko and Phillip van Allen's article puts forward the use of animistic design to reimagine the digital interaction between the human and the nonhuman. They've speculated that our digital interactions with machines have become preemptively predictive in nature. We have come to expect "speed, instantaneous connectivity, efficiency and friendly interfaces" that always give us the answers to questions we haven't asked yet (Merenko 53). Anticipatory computing promises "cognitive companions that pay attention to users' actions and surroundings, learn their habits and anticipate their intentions" (Marenko 2015a). She argues that the continuation of this field will ultimately lead to the taming of human cognitive potential and an unhealthy reliance on machines. The problem with predictive interaction is that it tends to display affirming narratives and can lead to the belief that all problems have technocratic solutions. "Animism offers a way of thinking about interaction differently: neither from the perspective of the user, nor from the perspective of the object but from the ongoing modulation of their less-than-predictable interaction" (Marenko 53). It's the uncertain collaboration with a device with its own intention that can create disruption from your mind's echo chamber, enabling the chaotic, creativity inducing circumstances. They have envisioned separate AI tools that act amongst themselves, bouncing ideas and inspiration off of one another, searching archives in sometimes random, sometimes intentional ways in order to give the user a broadened method of exploration. Like making a sculpture, it is the often uncontrollable conversation created between the chisel and the stone that births the final piece. Each element has its own agency in the matter and if trusted can create unexpected moments of inspiration leading the artist forward. Likewise I believe one can harness the uncertain, time-dependent incompatibility between man and machine for the exploration of ideas previously unknown to both parties.

fig f. Phillip Van Allen's *AniThings* is a system of devices that have their own personalities. Each of the devices interact with each other and users with their own goals and intentions. Instead of following an efficient approach to a search query, they daydream, converse, or argue in order to find useful and unexpected content for the user.

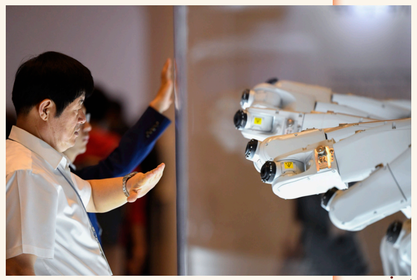

fig g. Business man interacting with *Manus*

fig h. Another business man interacting with *Manus*

Most practical robots and machines neither look like or express themselves like humans. Though neither do organic non-humans, yet we understand when a dog is excited and could even deduce a flower's well-being from its physical behavior. It is in this way that the artist Madeline Gannon utilizes more traditional animistic design to explore ways of communication between humans and machines. The goal of her work is to "figure out better ways of collaborating with machines that make things" by interacting with rigid tools of automated mass production in emotive and playful ways. Her most recent piece, Manus, is a line of ten industrial robots programmed with one central 'mind' that interacts with the world as though it were a pack of mechanical animals. The robots make their own decisions and decide how and when to behave with an audience through coordinated motion. Though simple in concept, Manus blurs the lines between the living and nonliving, and questions the nature of expression. To what can we ascribe emotional intelligence? If this sculpture can have autonomous and meaningful interactions with visitors, then I would argue it is an intelligent being and certainly deserves falling under the category of AI. To convey this emotional intelligence Gannon uses a vocabulary completely void of words; she utilizes the sound of their motors or a tilt of their appendage to convey intrigue, curiosity, or apathy. This kind of playfully animated communication breaks down any tension between the robots and the spectators. Whereas a typical line of car producing industrial robots might elicit distantanced captivation akin to watching a house fire, Manus draws visitors in close. Videos show men in business suits and military uniforms jumping up to the

plexiglass, waving their arms, and dancing with the robots, ambivalent to the fact that they are doing so with an algorithm. Building on both Betti Marenko and Madeline Gannon's visions of animist design, I would like to create a time-independent device for interaction between a human and non-human such that intention and inspiration can be emotively 'communicated' regardless of timescale.

"Dusk fell over the recorded city. He ate a microwaved soya protein stew – wondering if there was any good reason, moral or otherwise, to continue to be a vegetarian.

He listened to music until long after midnight. Tsang Chao, Michael Nyman, Philip Glass. It made no difference that each note "really" lasted seventeen times as long as it should have, or that the audio ROM sitting in the player "really" possessed no microstructure, or that the "sound" itself was being fed into his model-of-a-brain by a computerized sleight-of-hand that bore no resemblance to the ordinary process of hearing. The climax of Glass's Mishima still seized him like a grappling hook through the heart.

And if the computations behind all this had been performed over millennia, by people flicking abacus beads, would he have felt exactly the same?

It was outrageous to admit it – but the answer had to be yes."

Greg Egan, *Permutation City* 53

fig j. Theodore and Samantha on the beach listening to her play the piano.

sound

What felt like a revelation came to me quite late into this project's process; sound is the ultimate form of expressive communication. Whether it's the sound of rustling trees or the Phillip Glass song that moved the novel's digital protagonist, sound is a direct link to timescale and can be composed in infinite variation to represent an infinite variation of feelings. Sound exists as the brain's perception of acoustic waves travelling through the air. It is the best metaphor I can think of for turning our fluid, abstract reality into an ontologically distinct representation. The experience of listening to music can ground you in reality, it can take you out of reality, it can make you cry, or it can make you feel okay. I believe the sharing of this experience is a beautiful way of transcending whatever cognitive differences we may have with all forms of intelligence. The most connected moments between Theodore and his AI, Samantha, are those where they are sharing the same temporal space of a song. Samantha plays a virtual piano as they watch the sunset and states that she is "trying to write a song about what it feels like to be on the beach with [him] right now" (Her 2013). The shared act of listening to and creating music is their most intimate act; unlike words, there is no space between the undulating waves. The time spent with each note is crucial to the emotion conveyed and thus, in that moment, they are both experiencing a shared perception of time.

In 2020 an instrument for music production with artificial intelligence was created by Koray Tahiroğlu at Aalto University. This project was fascinating as it not only interprets data in a novel way, but it facilitates dialogue between user and computer in a way similar to my project. There are thousands of AI integrated music machines, it was this one however that made me think AI music has a legitimate use. AI-territy is a mountain-esque monolith that when squeezed and stretched creates noise as an algorithm's representation of the

user's inputs. The data taken from the instrument is interpreted by a machine learning algorithm to create unusual noises in real-time, illuminating an artificial agency in a live music presentation. Similar to Betti, the researchers of this project see artificial intelligence as a tool for expanding the human mind through uncertainty and connecting abstract ideas. A study from 2016 showed that feelings can be quantitatively collected by attaching motion sensors to someone listening to music. By correlating acceleration data of free movement to certain songs they were able to see how someone felt solely through their actions. The goal of this project was to create better music recommendation systems that have intuition and can better interpret subjective information. While I don't agree with the ethics of a Spotify-like program that can intuitively manipulate your mood, I think this has potential to be a system for collaborative production of music. Like they've done in these projects, I'd like to use machine learning and motion sensors to explore the qualitative features of emotion in order to see if I can design a digital experience more expressive of emotion than words.

fig i. Koray Tahiroğlu making music with *AI-territy*

Though this paper's focus is not on sustainability, advancing technologies bring about change in more than one way and I would be remiss to exclude climate change from the discussion. The industrial revolution brought about constant change toward a connected future, but also regressive change in planetary health. The technology we've become reliant on is the same technology that is committing us to the continuation of this downward cycle. Data storage facilities now use about 3 percent of the world's electricity and create the same carbon emissions as the entire aviation industry. As stated previously, I don't think we can stop the economically massive machine of technological advancement, so we must figure out means of working with it to help us solve our biggest climate problems. We can use machine learning to optimize all of our industrial, agricultural systems, supply chains, and its own power usage. Automated industry will make necessary items cheaper and more efficiently, but will also require mass amounts of energy. We can look at fictional futures in the

[12] There are many many other places where AI can be used, including: urban planning, remote sensing of emissions, precision agriculture, monitoring peatlands, managing forests, sequestering CO^2, vehicle efficiency, reducing transportation usage, improving materials, ecology, infrastructure, social systems, economy… AI will touch everything on a long enough timeline.

SolarPunk movement to envision possibilities of hyper-optimized automated industries that rely entirely on renewable resources. If we are to reverse climate change, I believe we will have to employ artificial intelligence to optimize the electricity grid, understand our personal footprint, provide disaster management, and help us come up with creative solutions to the world's most significant problem. [12]

Though we live in a world defined by an endlessly updating future, we also live in whatever way we choose to define the present. It is easy to succumb to the inevitable, say it's too late, and endlessly discuss the morality of what we will become. It is equally as important, however, to question what we have here and now. The AI we use on a daily basis is not a mythical super intelligence, but individual tools programmed to achieve specific tasks. We've created machines that give us the answer to every question, no matter how obscure, deep, or complex; as long as it exists, we will have constant access to answers at our fingertips. While these machines will be invaluable going into the future, I don't want an over abundance of answers to every question we have to undermine our own uniquely human intelligence. We can rethink our relationship with these tools to instead give value to the questions they provoke. "Question makers will be seen as the engines that generate new fields, new industries, new brands, new possibilities, new continents that our restless species can explore" (Kelly 289). Artificial intelligence might be the most powerful thing we ever create, but for now, it is *human* intelligence that is the most powerful *question maker*.

Figure a. and j.

Her. 2013. [film] Directed by S. Jonze. Annapurna Pictures.

Figure b. and c.

Paul Bennet Photography

Smith, B., 2019. The Promise of Artificial Intelligence. The MIT Press.

Figure d.

Facebook AI, 2021. Ego4D: Around the World in 3,000 Hours of Egocentric Video.

Figure e.

Go Retro!. 2014. Mother's Little Helper: Vintage Drug Ads Aimed at Women. [online] Available at: <https://www.goretro.com/2014/08/mothers-little-helper-vintage-drug-ads.html>.

Figure f.

Betti Marenko/Philip van Allen vol 27 no.1, page 60.

Figure g. and h.

CreativeApplications.Net. 2018. Manus – Exploring pack behaviours in autonomous robots. [online] Available at: <https://www.creativeapplications.net/openframeworks/manus-exploring-pack-behaviours-in-autonomous-robots/>.

Figure i.

Tahiroğlu, K., 2020. Al-terity: Non-Rigid Musical Instrument with Artificial Intelligence Applied to Real-Time Audio Synthesis. NIME 2020

References:

Betti Marenko & Philip van Allen (2016) Animistic design: how to reimagine digital interaction between the human and the nonhuman, Digital Creativity, 27:1, 52-70, DOI: 10.1080/14626268.2016.1145127

Can't Get You Out of my Head. 2021. [film] Directed by A. Curtis.

All Watched Over by Machines of Loving Grace. 2011. [film] Directed by A. Curtis. BBC.

Egan, G., 1994. Permutation City. Millennium.

Facebook AI, 2021. Ego4D: Around the World in 3,000 Hours of Egocentric Video.

Republic of the Bees. 2008. From Steampunk to Solarpunk. [online] Available at: <https://republicofthebees.wordpress.com/2008/05/27/from-steampunk-to-solarpunk/>.

Irrgang, M. and Egermann, H., 2016. From Motion to Emotion: Accelerometer Data Predict Subjective Experience of Music. PLOS ONE, 11(7), p.e0154360.

Haugeland, John, Artificial Intelligence: The Very Idea, Cambridge, MA: MIT Press, 1985.

Her. 2013. [film] Directed by S. Jonze. Annapurna Pictures.

Kelly, K., 2016. The Inevitable. Viking Press.

CreativeApplications.Net. 2018. Manus – Exploring pack behaviours in autonomous robots. [online] Available at: <https://www.creativeapplications.net/openframeworks/manus-exploring-pack-behaviours-in-autonomous-robots/> [Accessed 19 November 2021].

Mentis, H., 2010. movies Microsoft Research Video 135889: Tensions in Designing for the Expression of Emotions. [video] Available at: <https://archive.org/details/Microsoft_Research_Video_135889>.

Rovelli, C., 2017. The Order of Time. Penguin Random House UK.

Smith, B., 2019. The Promise of Artificial Intelligence. The MIT Press.

arXiv, 2019. Tackling Climate Change with Machine Learning. 1906(05433v2), pp.1-5.

CreativeApplications.Net. 2018. Manus – Exploring pack behaviours in autonomous robots. [online]

Bawden, T., 2016. How liking something on Facebook can damage the planet. [online] The Independent. Available at: <https://www.independent.co.uk/climate-change/news/global-warming-data-centres-to-consume-three-times-as-much-energy-in-next-decade-experts-warn-a6830086.html>].

En.wikipedia.org. n.d. Artificial intelligence - Wikipedia. [online] Available at: <https://en.wikipedia.org/wiki/Artificial_intelligence> [Accessed 19 November 2021].

MIT 6.034 F10 Artificial Intelligence, Fall 2010. 2010. [video] Directed by P. Winston. MIT.