EDITORS: Gerd Kortuem, g.w.kortuem@tudelft.nl
Evangelos Niforatos, e.niforatos@tudelft.nl

DEPARTMENT: IOT NEWS

Let us Break the Time Barrier—Anytime Computing

Florian Michahelles, *TU Wien, 1040, Vienna, Austria*

Philipp Wintersberger, *University of Applied Sciences Upper Austria, 4600, Wels, Austria*

Thanks to the advances in communication technologies, the costs of connecting to our beloved ones over distance have become negligible. The provision of bandwidth, access to connectivity, and integration of cameras into almost any mobile device allows us to perceive what is happening with our communication counterparts visually. The emergence of telepresence robots even provides us with a remote presence in distant locations. Virtual and augmented environments blend virtual information worlds and physical settings into each other. All these developments together allow better communication and collaboration over distance. During the COVID-19 pandemic, an accompanying cultural and organizational transformation has also been triggered, allowing us to embrace and leverage these technological developments and thus enabling a new way of working. Employees fulfilling their duties from their homes has become the new normal. The traditional office with assigned seating is getting replaced by coworking spaces used for specific occasions, rather than being used on a daily basis. Business travel is losing importance due to in-person gatherings changing to online meetings. In a nutshell, the constraints of space determining presence at a specific location are mitigated by communication technologies that are bringing people together virtually over distance.

Complementing this opportunity to break with the space constraint, could we also make better societal (and maybe individual) decisions via breaking boundaries of *time*? First we might ask, "why should we?"

The psychologist Daniel Gilbert has argued that humans being good at predicting and escaping immediate dangers, like every mammal, has helped us survive as long as we have. Facing an immediate threat running down the street triggers us to run the other way. Our brains have been configured to treat the future as if it was the present. We can take action to save for retirement or floss our teeth for a better future outcome. We do not respond to long-term threats with nearly as much diligence as we do to clear and present dangers. The COVID-19 pandemic has illustrated the challenge of forming consensus on measurements to curtail the spread of the virus when the effect could not be observed immediately. Another example is climate change, where costly, immediate societal reduction of demand and sustainable provision could shift global temperature change, but only decades later. Overcoming short-term thinking, forming better decisions, and empathizing with future generations should be worthwhile efforts.

HUMANS, TRAPPED IN THE PRESENT

The so-called marshmallow experiment has substantiated this human trait of near-term focus: Mischel and his team[1] created a delayed gratification experiment in 1972, where young participants would sit in front of a bowl of marshmallows. They could pick one marshmallow immediately; however, their reward would be doubled if they could control their desires until a bell rang 15 minutes later. The study's claim that subjects' ability to practice more self-control would predict higher SAT scores, lower body mass and less consumption of drugs has been disputed. Nevertheless, the study does provide evidence for the general human trait of favoring immediate reward over long-term consequences.

Self-continuity describes the ability to project oneself back into the past and forward into the future, despite the potential impacts of time and the environment. Future benefits are often perceived as further

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away, favoring present decisions.[2] McLure[3] found a brain is divided into an emotional part and a logical part. The logical brain reveals future consequences, and the emotional brain prioritizes the immediate benefit of the current action. Can *simulating* future scenarios increase the saliency of selfish motivations, such as reputational concern, to promote prosocial or sustainable behavior, ultimately helping humanity to resolve pressing and complex long-term problems? Can we use computer technology to break the barrier of time?

TIME-TRAVELING IN VIRTUAL ENVIRONMENTS

According to recent research, mixed reality could become one ingredient in breaking the barrier of time. Fender and Holz[4] recently presented the concept of an "Asynchronous Reality," a method used to avoid disturbing users deeply immersed in virtual environments. Instead of letting bystanders invade the users' virtual world, the bystander would be recorded (for example, when delivering an object). Later, the immersed user can see these recordings in VR as if the events initiated by the bystander are happening only then. Other researchers have described systems where people who have passed away could "survive" in virtual worlds. Kuyda[5] trained a conversational AI with texts written by a friend who died in a car crash to be able to chat with the friend, thus creating the illusion of communicating with a person from the past. A similar concept has been presented by Artstein et al.,[6] who built a system where people can interactively communicate with a holocaust survivor. Artstein et al. received positive feedback from users about "time-offset interactions." Such interactions help people to better empathize with others, but potentially, also with another "self." The so-called "proteus effect"[7] describes how a user's behavior in a virtual environment can be modified by changing the characteristics of an avatar. For example, a more attractive avatar led to study participants being more friendly to strangers than when the participants were provided with less attractive avatars. Another study by Peck at al.[8] has shown that users' racial biases can be decreased by representing them with avatars of different skin colors. Finally, Choi[9] has discussed how imagining future episodes (in the context of prosocial behavior) can influence present decisions. Thus, it is fair to hypothesize that immersing users in episodic simulations to interact with, or step into, the feet of future selves and others may be a viable approach to overcome short-term thinking, empathize with future generations, and ultimately make better decisions in the present.

POTENTIAL APPLICATIONS

VR time traveling could help us overcome the natural limitations of short-term dominance of the human brain, which may enable us to address better problems influenced by behaviors on a long time scale. The concept is not limited to future issues like climate change or health issues; immersion in the past to inform future decision making is also possible. In particular, we envision the following applications:

The past and future self: We frequently struggle with self-perception. Revisiting past situations as simulations could help us better understand decisions we have made in the past. Some decisions may be regretted later, and time-traveling could help us realize that these decisions might have been rational and reasonable at the time they were made. At the same time, we could experience a future to see how our behaviors might influence us in the long run. For example, visualizing the future adverse effects of smoking, limited exercising, or other health-related behaviors might impact present-day behavior.

The past and future others: For most people, it seems bizarre that the population of democracy could actively choose to switch to a misanthropic authoritarian society, as happened with the German National-Socialistic state just a century ago. One can hardly imagine being "on the wrong side" of history, and families have suffered after realizing that their parents or grandparents once were obeying racist killing machines. Traveling back and immersing ourselves with the people involved, both victims and perpetrators, could help us better comprehend how authoritarian systems evolve, potentially helping to prevent similar evolution in the present (recent events demonstrate that modern societies are not immune against authoritarian tendencies). Further, we could travel into the future to step in the footsteps of our simulated grandchildren and their descendants to see how decisions that we perform today may affect their well-being. How would we feel about our choices (e.g., taking the airplane for a weekend trip, adopting a daily meat-based diet) when we see our own family members suffering on an unlivable future planet?

TOWARDS ANYTIME COMPUTING

The development of artifacts that make past and future events more tangible may help us not only better understand ourselves, family members, and community.[10] Our logical brain could be further supported by emotional

underpinnings. Pervasive computing can be applied to morph our existing environment, captured by sensors, into a simulated future or past driven by virtual agents acting on data documenting the history. Would not it be great to visit places and perceive their ancient character in a realistic way, live and in real time?

We believe "anytime computing" could provide novel research topics for the pervasive computing community to focus on.

Tangible experiences: How to make long-term threats as urgently perceivable as short-term threats? How to create novel, strong virtual sensations that users are willing to perceive and that convey actionable information? How to plausibly alter these experiences based on a user's present behavior?

Evidence-based experiences: How to provide emotional access to a transparent understanding of cause and effect? How to make the rationale of a past or future experience transparent? How to make experiences believable and valid?

Toolkits: What are the underlying principles of experience across domains? How might toolkits be developed that lower barriers to developing experiences?

Boundaries: What are technical and ethical boundaries? What are potential cases of abuse? When do experiences become manipulative? What should be the guidelines for "anytime computing"?

Effectiveness: To what extent can past and future experiences overcome our short-term thinking, yield better personal and societal decisions and increase empathy?

We are currently in the initial stage of defining appropriate uses cases that can be implemented with existing technology so that we can evaluate prototypes soon. We invite you to join us in exploring the potential of anytime computing!

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FLORIAN MICHAHELLES is a professor of ubiquitous computing at TU Wien, 1040, Vienna, Austria. Michahelles received his Ph.D. degree in computer science from ETH Zurich, Zurich, Switzerland. He is the corresponding author of this article. Contact him at florian.michahelles@tuwien.ac.at.

PHILIPP WINTERSBERGER is a professor of interactive systems at the University of Applied Sciences Upper Austria, and working on his habilitation at TU Wien, 1040, Vienna, Austria. Wintersberger received his Ph.D. degree in human–computer interaction from Johannes Kepler University, Linz, Austria. Contact him at philipp.wintersberger@fh-hagenberg.at.