

## Let's break the time barrier – anytime computing.

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Thanks to the advances in communication technologies, the costs of connecting to our loved ones over distance have become negligible. The provision of bandwidth, access to connectivity, and integration of cameras into almost any mobile device allow us to perceive what's happening with our communication counterparts visually. The emergence of telepresence robots provides us even 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, also the accompanying cultural and organizational transformation has been triggered, allowing us to embrace and leverage these technological developments 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 being replaced by coworking spaces used for specific occasions rather than on a daily basis. Business travel is losing importance due to gatherings getting turned into online meetings. In a nutshell: the constraints of space determining presence at a specific location are mitigated by communication technologies bringing people together virtually over distance.

Contrasting with this opportunity to break with the space constraint is an overwhelming overload with events happening simultaneously: hence, can we also use technology to overcome the limitations of time.

Well, the question before that is, 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 present. We take action to save for retirement or floss our teeth for a better future outcome. However, we don't respond to long-term threats with nearly as much stringency as we do to clear and present dangers. The recent COVID-19 pandemic has illustrated the challenge of finding majorities for forming decisions on measurements to curtail the spread of the virus when the effect can be observed only at a delay of about two weeks later. Not to speak about climate change where immediate societal reduction of demand and sustainable provision takes a direct toll of cost but could be attributed to a shift in global temperature change only decades later. Overcoming short-term thinking, forming better, and sympathizing with past and 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 in 1972, where participants would sit in front of a bowl of marshmallows. They could pick one immediately; however, their reward would be doubled if they could control their desires until a bell rang for 15 minutes. 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 away, favoring present decisions [2]. McLure [3] found reasons in our brain divided into an emotional part and a logical part. The logical part would reveal future consequences, with the emotional brain prioritizing 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 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 resolving this issue. Fender and Holz [4] recently presented the concept of an ‘Asynchronous Reality’ to not disturb users deeply immersed in virtual environments. Instead of letting bystanders invade the users’ virtual world, they would be recorded (for example, when delivering an object). Later on, the immersed user can see these recordings in VR just as if the events initiated by the bystander would happen now, creating the illusion of the bystander (or, depending on the perspective, the user) ‘time traveling’. Other concepts describe systems where people who 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 him, also creating the illusion of communicating with a person in 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. They 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 representation made study participants more friendly to strangers than less attractive avatars. Another study by Peck et 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, sympathize with future generations, and ultimately perform 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 but also allows immersion in the past. In particular, we envision the following applications:

***The past and future self:*** We frequently struggle with self-perception. Immersing in our past selves 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 very rational from the former perspective. At the same time, we could experience a future to see how our behaviors will influence us in the long run. For example, to see the adverse effects of smoking, limited exercising, or other health-related behaviors.

***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 with people involved, both victims and perpetrators could help us better comprehend how authoritarian systems evolve, potentially helping to prevent them from evolving in the present (currently, there are multiple examples demonstrating that modern societies are not immune against authoritarian tendencies). Further, we could travel into the future to step in the footsteps of our grandchildren and their descendants to see how the decisions we make today affect their well-being. How would we feel about our choices (e.g., taking the airplane for a weekend trip, or 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 better understand ourselves, family members, community, but also strangers [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. With augmented or diminished reality, the concept can be applied to less serious use cases such as tourism. Wouldn't it be great to visit places and perceive their ancient character in a realistic way, live and in real-time?

We believe establishing a notion of 'anytime computing' could provide a new greenfield for the pervasive computing community to focus on a number of compelling research questions.

**Tangible experiences.** How to make long-term threats as urgently perceivable as short-term threats? How to create sensations users are willing to perceive and 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? Which toolkits could be developed to 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 decisions and increase empathy of behaviors?

We are currently in the initial stage of defining appropriate use cases that can be implemented with existing technology so that we can evaluate first prototypes soon - so, let's break the barrier and explore the opportunities of anytime computing!

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