Artificial Life in a Challenged World

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"Life clearly does more than adapt to the Earth. It changes the Earth to its own purposes. Evolution is a tightly coupled dance, with life and the material environment as partners. From the dance emerges the entity Gaia."
James Lovelock

Life in a Challenged World

Our world is in distress. At an alarmingly increasing pace, we are witnessing the effects of global warming and climate change: record temperatures, droughts, melting of glacial and polar ice and large scale natural disasters are only few of the many clear indicators of the burden that human life puts on our Planet's climate systems (Masson-Delmotte et al., 2018). Rapid climate change and the loss of natural habitats to make space for humanity's growing resource needs are causing biological mass extinctions of unprecedented scale (Ceballos and Ehrlich, 2018). With a global human population size predicted to plateau at around 11bn people within the next 50 to 80 years (United Nations, Department of Economic and Social Affairs, Population Division, 2017) and a growing number of threshold countries adopting consumerist life styles, we can only expect the strain on our ecosystem to intensify.

Global challenges do not stop at our door steps. Despite huge gains in global economic output, there is evidence that our current social, political and economic systems are exacerbating inequalities, rather than reducing them (Dabla-Norris et al., 2015), which is an increasing cause of political unrest. The global financial crisis of 2008 revealed significant weaknesses in the financial system and the vulnerabilities of a single interconnected global market (Rose and Spiegel, 2012; Battiston et al., 2016). The scale of the employment challenge is vast, with an estimated 200 million people unemployed globally. Even comparably modest societal goals such as race and gender equality are far from being achieved.

For the majority of humans, the Anthropocene might soon no longer be a comfortable spot to live in. While some authors raise the question whether a collapse of our global civilization can be avoided (Ehrlich and Ehrlich, 2013), other scientists worry whether humanity will inevitably push Earth beyond limits where it would be unable to sustain life in the manner that we know at all (Ripple et al., 2017).

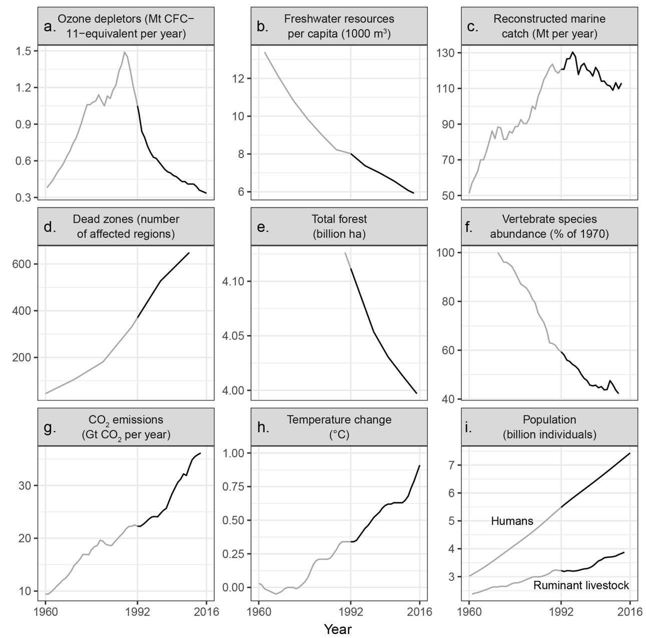

Figure 1: Trends of diverse environmental indicators over the last 50 years. None has reversed since the "World Scientists' Warning to Humanity" had been issued in 1992. Yet, the reversal of ozone depletor concentrations (panel a) is a proof by example that concerted policy making can in princple overcome ecological problems on a global scale. Reproduced with permission from Ripple et al. (2017).

Can Artificial Life Help Tackle Societal Challenges?

Historically, the discipline of Artificial Life has often been regarded by its adversaries as an academic leisure, where scientists investigate dreamt up worlds with little to no application to real life. We believe this view to be a gross misconception that our community should set straight: Artificial Life is the study of Life driven by investigating its first principles. How could we possibly remain unattached or shy away, if the subject at the very heart of our studies is at stake? Yet, it is not immediately obvious how our community can confront the challenges that humanity is currently facing. What unique skills and perspectives can the Artificial Life community bring to the table?

As organizers of an ALIFE conference on the theme "How Can Articifical Life Help Solve Societal Challenges" we do in fact believe that our interdisciplinary and constantly self-innovating discipline brings together a set of skills and perspectives with a unique potential to tackle some of the most pressing societal challenges of our times.

Firstly, we believe that more than many other disciplines, ALIFE embraces systems thinking at its core. Rather than perceiving our current societal challenges as isolated problems that can be solved independently using linear thinking, we recognize them as interconnected symptoms of a strained system of systems that about to be pushed out of their local area of stability. The formal application of systems thinking to global challenges dates almost 50 years back, when Meadows et al. (1972) developed Systems Dynamics to investigate the interplay of feedback loops in our intertwined socio-economical and ecological systems. Their basic conclusion – that humanity inevitably reaches the carrying capacity of planet Earth – still holds to date, and has been restated with slightly updated facts ever since.

However, such nonlinearities do not come easy to our human minds, and conclusions from these studies have not yet affected policy making and societal norms and habits to the extent necessary. We believe one of the core competencies of ALIFE – mathematical modelling and simulation – to be a vital tool, for understanding the nonlinear nature of our current crisis, as well as for educating the public and policy makers. Model based decision support systems and participatory modelling techniques are key elements to this process (Gilbert and Bullock, 2014; Sayama and Dionne, 2015).

Importantly, the predicament we are facing is not just ecological in nature, nor societal, nor economic, nor bound to any other single discipline – it is truly trans-disciplinary. Few other scientific communities have interdisciplinarity embodied as deeply and drastically as ours (Aicardi, 2010): not only do we engage without reservations in discourses with academics from various departments and faculties, ALIFE also has close bonds with the arts, music, game development and design. Maybe we should reflect on this strength of ours, and provide more domain-segmented academic research areas with our 30 year experience in crossing disciplinary boundaries (Dini et al., 2011).

Thirdly, we believe that ALIFE's 'central dogma' that life is an emergent complex adaptive system that exhibits dynamical hierarchies and open-ended evolution is another indispensible ingredient when addressing our current problems. The ALIFE community is aware of the complex dynamics that unfold in self-organized, self-regulating multi-agent societies. We know that neither biological systems, societies, nor markets react proportional in response to stimuli and are thus notoriously hard to steer by means of top-down regulations. Yet, ALIFE understands that sudden phase transitions are not only found in our current climate crisis, but that social learning and cultural revolutions equally proceed in series of punctuated equilibria that can open up for unexpected jumps into the next adjacent possible.

The industrialized world currently experiences the rapid growth of a new cultural grassroot movement that turns its back on established consumerism to instead adopt a low-carbon, zero-waste life-style. Such movements, paired with the loud voices of young adults striking all over the world for policy makers to finally take actions, might ignite a spark of hope among the desperate predictions that scientists have produced. But what determines the success or failure of such cultural revolutions? Which factors most strongly affect their speed of uptake? What influences how such movements ultimately shape national and global policy making? We believe that these and similar questions can be readily addressed and turned into actionable recommendations using our ALIFE toolbox. At the same time, we can reach out to these groups from a scientific point of view.

The shear amount of societal themes discussed at this year's conference – from social learning, human and cultural evolution, social dynamics and simulation to financial market dynamics and policy making – demonstrates how heavily our community is indeed long concerned with this general agenda. And what better tools to draw from than the union of dynamical systems theory, game theory and agent-based modelling, artificial intelligence and machine learning, evolutionary and unconventional computing that together constitute a good part of the ALIFE methodology?

A main concept of ALIFE is not the study of life as it is (with all its evolved facets and structures that sometimes only make sense in the context of this evolutionary history) but the analysis of deliberately simplified life-like systems. Two main intellectual challenges have to be mastered: First, principles of life found in our real world have to be mapped into artificial systems. Thereby, depending on the research question, only a small subset of important principles may be taken into account in order to highlight specific aspects. Second, we have to answer to what extent results found in artificial systems can be mapped onto the behavior or structures of the real world. The first challenge certainly appeals to the creativity of the ALIFE community and resulted in a rich variety of approaches. The second challenge turns out to be harder and certainly requires an even closer collaboration with those experts who know the real world. However, ALIFE will only achieve its full potential if both challenges are mastered.

Perheaps most importantly, compared to many other academic disciplines, the ALIFE community is a notoriously free-spirited crowd. In our studies, we typically do not let hair-splitting details stop us from pushing pie-in-the-sky ideas. This capability of ALIFE to be imaginative and to think out of the box might perheaps be the most important quality that we can offer to the scientific community and society at large, by embedding our critical creative thinking and our free spirit in all potential solution fronts. Be it in the form of alternative societies and e-democracy (Speroni di Fenizio and Paterson, 2010; Aragón et al., 2017), living technology that incorporates the core features of life (Bedau et al., 2009; Armstrong, 2009), bioremediation and terraforming programmes based on artificial cells (Solé, 2015), or even a coming form of hybrid, biological-technical life forms that could form the basis of a post-human era.

Artificial Life is understood as *"The study of life as it could be, rather than life as we know it."* At times where life as we know it is threatened to cease to exist, we urge the ALIFE community to take this credo to the next level: Let us dream up what our very own life as human species could be, and how we might be able to recreate the harmonious dance that life and the material environment ought to perform.

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