Artificial Life XII:
The 12th International Conference on the Synthesis and Simulation of Living Systems

This is the proceeding for the Artificial Life XII Conference (`http://www.alife12.org/`), hosted by the Center for Fundamental Living Technology (FLinT) (`http://www.sdu.dk/flint/`) at University of Southern Denmark, Odense, August 19-23, 2010. Twenty three years ago in September 1987, the first Artificial Life Workshop was held at Los Alamos National Laboratory and the subsequent Alife workshops and conferences have been hosted in the US eight times (Los Alamos 1987, Santa Fe 1990 & 1992, MIT 1994, UCLA 1998, Reed 2000, Boston 2004), Japan once (Nara 1996), Australia once (Sydney 2002), England once (Southampton 2008) and now in Denmark (Odense 2010).

What is different about Alife XII?

You may have noticed that we have switched sequence of the concepts "Simulation" and "Synthesis" in the title of the conference to emphasize some changes within our community. First of all, the Alife XII submissions consist of a significantly higher fraction of wet Alife papers than at any earlier Alife conference. It is a pleasure to see how the communities from wet and soft Alife are increasingly engaging with each other. These submissions are also congruent with a clearer view in the broader scientific community on how we might create life either from scratch or through top-down design [1, 2, 3]. This trend is also reflected by a number of recent international collaborations across the top-down and the bottom-up communities, often sponsored under the title of synthetic biology.[1]

Living processes have been implemented and studied for many years in soft Alife systems (living processes implemented on computers), but the emergence of replicating programs from noisy computational environments remain an open issue. Significant progress has also been made for life-like robotics systems, for example through the development of polymorphic robots, where e.g. simple self-assembly, self-replication as well as complex collective behavior now have been obtained [4, 5].

In general, we see more integration between wet, hard, soft, and mixed living systems both within the Alife community and across the broader scientific and technological landscapes. This is in part captured by the definition of emerging living technology which comprises all technological applications of living and life-like processes at all levels [6].

As the Alife community inches closer to an understanding of life as a physical process by constructing living processes, we are also increasingly assessing the technological implications of the ability to engineer systems, whose power is based on the core features of life: robustness, adaptation, self-repair, self-assembly, and self-replication, centralized and distributed intelligence, and evolution [7].

In the coming years, we will likely see an accelerated movement towards more life-like, living, and intelligent processes as well as their integration across many technologies to form new biology-technology

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[1]E.g., the European Science Foundation sponsored synthetics biology workshop on "Streamlined and synthetic genomes", November 16-17, 2009, Valencia, Spain. The Los Alamos National Laboratory sponsored synthetic biology workshop, June 28-29, 2010, Los Alamos NM, USA.

ecologies, that also include human institutions. If implemented appropriately, these new systems, technologies, and organizations could become more in tune with the needs of human society and the natural dynamics of the biosphere.

These developments are emerging from a knowledge convergence between a variety of sciences and technologies which we, within the Alife community, may group into (i) wet carbon-chemistry-based systems, (ii) computational and robotics based, ICT (information and communications technology) systems, and (iii) human organizations and institutions dominated by culture and human nature.

As part of the Alife XII program, we have scheduled a session "Looking backwards, looking forwards" to address the scientific questions related to these developments. Ten years have passed since the last Alife community status report [8, 9, 10], and we hope that this conference program can contribute to updating the critical open Alife questions. The day after the conclusion of the Alife XII conference, we have a one-day workshop for a similar discussion focused on the technological implications of Alife. Part of this discussion will be open to the public [11].

We should also emphasize that after 23 years, a hallmark for Alife community is still its scientific breath and inclusiveness. The Alife conferences clearly continue to act as a Big Tent, where scientists from many different disciplines and domains meet to present results and exchange ideas. This unique community feature has historically made the Alife community highly innovative, however it also makes peer review difficult as scientific methods vary dramatically across the many domains and disciplines. This breath also causes problems when papers need to be categorized into sessions as most papers in this volume could fit under several of the conference themes.

Background for Alife XII

For Alife XII 156 out of well over than 200 contributions (papers and abstracts) were accepted in the peer review process. These papers and abstracts represent authors from 34 countries and they consist of 152 (= 156 presentations - 4 plenary talks) contributed talks in four, and at times five, parallel sessions. All contributions have 15 minutes for their presentation and five minutes for discussion. The contributed plenary talks have 40 minutes. Alife XII also has a vibrant Poster Session, which is a crucial component of the Conference.

In addition to the peer reviewed presentations, Alife XII has six Satellite Events, which are proposed and organized by individuals and groups from the community. Traditionally, these workshops add an important dimension to the Alife meetings due to their free format and often more exploratory topic selection. Often, radically new ideas are presented in these workshops or tutorials on specific topics and explored in more details than regular peer reviewed presentations allow.

In order to assemble the Alife XII conference program, we have harvested as much domain and expert knowledge as reasonably possible. This process started well before the first call for papers with a call for contributed themes, where we consulted the invited Scientific Advisory Committee (SAC) for advice. The Organizing Committee (OC) solicited the SAC, which effort we are deeply indebted for. The Alife XII SAC consists of:

Chris Adami	Pascale Ehrenfreund	Andrés Moya
Martyn Amos	Takashi Ikegami	Ole Mouritsen
Wolfgang Banzhaf	Martin N. Jacobi	Peter Nielsen
Mark Bedau	David Krakauer	Norman Packard
Jim Boncella	Doron Lancet	Rolf Pfeifer
Liaohai Chen	Kristian Lindgren	Vitor Dos Santos
Greg Chirikjian	Jerzy Maselko	Andrew Shreve
David Deamer	John McCaskill	Ricard Solé
Peter Dittrich	Chris Melhuish	Richard Vaughan

The SAC together with the OC proposed a variety of conference themes and the SAC also took part in the multiple conference announcements.

Upon submission, authors were asked to attribute their submission to several of these conference themes. In response to these preliminary assignments, the original themes were slightly revised to more closely match the accepted contributions. A group of 18 track organizers were asked to vote for the contributions potentially pertaining to their themes, and to suggest coherent sessions based on these submissions. This voting was performed using online spreadsheets (Google documents). The Pareto front of the track organizer votes identified few areas of strong overlap – mainly in the area of wet artificial life. For these areas, the session assignment was done jointly by the responsible track organizers. At this stage 113 out of the 152 contributions could be assigned to the unique highest bidder. The remaining 39 submissions with conflicting votes were then assigned in a way that lead to the most consistent sessions. In only five cases, we overruled the bare votes in favor of coherent session themes. However, it should be noted that many contributions fit well within several of these themes due to the interdisciplinary character of the Alife community.

This collective intelligence process resulted in the following themes (with theme organizer names):

Chemical Self-Assembly and Complexity (Jerzy Maselko)
Origin of Life (Mark Dörr & Bruce Damer)
Bottom-up Synthetic Cells (Pierre-Alain Monnard)
Systems Biology (Luis Delaye)
Biological and Chemical Information Processing and Production (John McCaskill)
Artificial Chemistries (Wolfgang Banzhaf)
Minimal Cognition and Physical Intelligence (Martin Hanczyc)
Evolutionary Dynamics (Chris Adami)
Theoretical and Computational Frameworks (Peter Dittrich)
Complex Networks (Carlos Gershensen & Mikhail Prokopenko)
Ecology (Seth Bullock)
Collective Intelligence (Johan Bollen)
Emergent Engineering (Norman Packard)
Intelligence and Learning (Takashi Ikegami)
Robots (Kasper Støy)
Socio-Technical Systems (Kristian Lindgren)
Philosophy (Mark Bedau)

We have tried to organize the sequence of conference topics from lower to higher levels of organization with a variety of methods themes sandwiched in between.

Four keynote presentations – by Christian de Duve, Tetsuya Yomo, John McCaskill, and Serge Kernbach – provide overarching perspectives on the origins of life, artificial cells, the connection between biochemistry and computational hardware and software as well as robotics, covering the classical wet, soft, and hard artificial life research areas. In addition to the invited keynote presentations, Alife XII also features contributed plenary talks. Reviewers, theme organizers and the organizing committee jointly suggested candidates for these presentations. Four plenary, contributed presentations were picked by the organizers to ensure an overall balanced conference program. Unfortunately, many other papers deserving to be highlighted as plenary talks could not be accommodated.

The review process was conducted and coordinated utilizing the distributed online tool EasyChair (http://www.easychair.org/), which the organizers can recommend for reviewing many conference paper and abstract submissions. We should stress that the assembly of the conference program would have been impossible without the fantastic work of the 135 Alife XII submission reviewers. The OC is deeply indebted to all of them and they are separately acknowledged on the next pages.

It is our belief that the resulting review process and conference program – a true child of bottom-up collective intelligence – benefited significantly from the participation of the many domain experts. It would have

been very difficult to assemble a theme-based program using a traditional top-down approach. The bottom-up process ensures a program organization, that reflects the highly diverse current activities within the Alife community. The disadvantage of this collective intelligence based program assembly process is that more time and effort is spend by more people.

We, the Alife XII OC, sincerely hope you will find these proceedings both useful and inspirational and that you will enjoy the conference.

Harold Fellermann (Alife XII co-chair)
Mark Dörr
Martin Hanczyc
Lone Ladegaard Laursen (Alife XII administrative chair)
Sarah Maurer
Daniel Merkle (Alife XII EasyChair chair)
Pierre-Alain Monnard
Kasper Støy
Steen Rasmussen (Alife XII chair)

August 2010, Odense, Denmark.

References

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[2] D. Gibson et al. (2010). Creation of a bacterial cell controlled by a chemically synthesized genome *Science*, 329(5987):52–56.

[3] Bedau, M. A. et al. (2010). Life after the synthetic cell *Nature*, 465:422–424.

[4] Zykov, V. et al. (2005). Self-reproducing machines *Nature*, 435(7038):163–164

[5] Ieropoulos, I. et al. (2005). EcoBot-II: An artificial agent with a natural metabolism. *Advanced Robotics Systems* 2(4):295–300.

[6] Bedau, M. A. et al. (2010). Living Technology: Exploiting Life's Principles in Technology. *Artificial Life* 16:89–97.

[7] Bedau, M. A. et al. editors (2010). *Living technology: 5 Questions*. Automatic Press, Copenhagen.

[8] Discussions: "Looking backwards, looking forwards" during the 7th Artificial Life Conference in Posrtland, Oregon, USA. See also Bedau, M. A. et al. editors (2000). *Artificial Life VII: Proceedings of the Seventh International Conference on the Simulation and Synthesis of Living Systems. MIT Press. Cambridge, MA*.

[9] Bedau, M. A. et al. (2000). Open problems in artificial life *Artificial Life* 6:363.

[10] Rasmussen, S. et al. (2003). Collective intelligence of the artificial life community on its own successes, failures, and future. *Artificial Life*, 9:207.

[11] http://science-society-policy.org/, see under events, August 24, 2010, "Putting people in the presence".