COVER

When all you have is a hammer, everything looks like a nail. The Swiss army knife is one way to depict the power that comes from having more than one viewpoint on a particular problem– and the power inherent in interdisciplinary approaches to the scientific study of complex subjects.

ILLUSTRATIONS

In search of answers to important questions, scientists invent tools, both physical and metaphysical, that can be applied to the phenomena of their study. With interdisciplinary research the toolbox is expanded and the questions are addressed from different angles simultaneously. Illustrations in this issue depict some scientific tools of the past, which helped expand our view of the world we live in, and opened up new possibilities for answering difficult questions. Now more than ever, those possibilities are likely to lie beyond the scope of a single scientific field.

Our industry collaborators include:

3Z · Ríkislögreglustjórinn · Össur · SAReye Search smart · Statistics Iceland · thorice securing longer shelf life · Aldin · Costner · CCP · Rögg · Mesher · Svarmi

Our research partners include:

German Research Center for Artificial Intelligence · IIIA-CSIC · Háskóli Íslands · Cadia · rannís

FROM THE DIRECTOR

DR. KRISTINN R. THÓRISSON

WOULD YOU LIKE SOME INTERDISCIPLINARITY WITH YOUR SCIENCE, SIR/MADAM?

How do we approach scientific research? This question has two distinct perspectives. One looks in the rearview mirror; the other looks out at the road ahead. We need interdisciplinarity in scientific research–in fact, there is no way around it! The only question is whether we let it work for us or against us. Some people realize this, but not everyone is convinced we must embrace it. To see why we may take a micro-lesson in the philosophy of science. Let's begin.

It happened like this. With no good answers for a specific class of phenomena, our questions tend to be philosophical in nature– What is matter? What makes an apple fall? What makes us sick? What is thought? Centuries of relentless philosophical ruminations led to the invention of what is called 'the comparative experiment'– the most reliable knowledge acquisition method humanity has discovered to date. When the early Greek philosophers started asking hard, deep questions about life, the universe, and everything, they set in motion a wave of endless benefits, including many things we'd rather not live without including penicillin, mobile phones, nylon stockings, nuclear power, airplanes, and healthcare. All scientific disciplines start out like this: indistinguishable from philosophy. They begin to take on their own identity when they start to produce specific tools for studying phenomena of particular interest, and when experimentation becomes relevant for answering specific questions. Without this approach, we would never have found the invisible microorganisms that can make us ill. Without it, you could neither buy multivitamins in the nearest pharmacy nor type "nearest pharmacy" into an application on your mobile phone and have it return something useful within one or two seconds.

A scientific field is defined in two ways, by the questions it asks and the tools it uses to answer them. In any active scientific, field there are questions that have been answered, and there are questions that remain unanswered. As a field matures, students hear less about the unanswered questions and more about the ones that were answered. These answers

"Looking at a [scientific] field in the rearview mirror dooms us to study the same old questions with the same old tools."

are available in the convenient form of textbooks, and they are highly amenable to standardized tests.

The role of science is to push our collective understanding of the world forward. We look at the road ahead and identify questions that remain unanswered, things we still don't understand. And here is a key insight: The tools and methods used for the old questions, whose answer we now know, may not work for the remaining unanswered ones. Just because the old scientific traditions worked way back then does not mean they will continue to work in the future. Unlocking the answers to persistent questions may be of an altogether different nature and require a completely different process.

So when we answer the question "how do we approach scientific research?" with an overview of what scientists in that field have done to date, and how– its tradition, accomplishments, and methods– we are historians looking in the rearview mirror. But the way philosophers and scientists of the past decided to group questions may not be the best way to slice and dice the world today– 100, 200, or 600 years later. Case in point: Computer science is less than 100 years old. We could not possibly have known 100 years ago that the most powerful tool for studying the far reaches of the cosmos or the universe's distant past would be computers, more specifically software simulations. To create this tool required a radically new way of looking at the world as a system of systems, a radical new calculation device (transistors), a radical new manufacturing process (miniaturization), and a radical new way of organizing calculations (software). None of this would have happened without interdisciplinary collaboration.

"The scientific endeavor is about unanswered questions. Looking at these questions from many perspectives increases our chances of finding good answers. That is interdisciplinary research. There is no other way."

The scientific endeavor is about unanswered questions. In this view, there is no such thing as a pure scientific discipline, just different ways to dice and slice a complex world. So as a scientist, don't think you're better off working solely with "your own kind." Your progress will slow down, and you'll be stuck in a blind alley before you know it. Rather than holding onto the wildly incorrect view that interdisciplinary research is somehow a luxury, a rare occurrence, or something we try to imply in our grant applications, let's embrace it as a way to do research. There is no other way forward.

HRAÐALLINN

HRAÐALL er stuðningskerfi Vitvélastofnunar Íslands fyrir sprota- og hátæknifyrirtæki sem vilja hraða tækniþróun sinni.

„Greining Vitvélastofnunar á gervigreind fyrir stýribúnað gætu tryggt Össuri áframhaldandi forystu á sínu sviði.“

„Samstarfið við Vitvélastofnun er mjög mikilvægt fyrir okkur hjá Mesher.“

„Sérsniðin algrím sem Vitvélastofnun þróaði fyrir okkur gerðu okkur kleyft að bjóða uppá vöru, sem er hvergi annars staðar til í heiminum.“

ÖSSUR

Stoðtækjaframleiðandinn Össur er leiðandi afl á heimsvísu við að bæta hreyfanleika fólks með tækni, rannsóknum og nýsköpun.

„Markmið þeirra, sem starfa hjá Össuri, er að hjálpa fólki að yfirstíga líkamlegar hindranir svo það geti notið sín til fulls og öðlast betra líf. Greining Vitvélastofnunar á því hvernig nota má gervigreind til að bæta stýribúnað og skynjun gervifóta og lausnir, sem starfsmenn stofnunarinnar þróuðu og afhentu Össuri, gætu falið í sér áður ókannaða möguleika sem nýta mætti til að ná markmiðum um aukin lífsgæði og tryggja að Össur verði áfram leiðandi á sínu sviði.”
Magnús Oddsson,
Forstöðumaður stoðtækjaþróunar hjá Össuri

Mesher

Sprotafyrirtækið Mesher framleiðir snjallsímaforrit, sem hjálpa fólki að kaupa föt á netinu. Hugbúnaðurinn, sem Mesher þróar, byggir á háþróuðum tölvusjónar- og vitvéla algrímum.

„Auk almennrar ráðgjafar hjálpar Vitvélastofnun til dæmis fyrirtækinu að setja tæknilegar áskoranir fram sem rannsóknarverkefni. Við þurfum að leysa mjög áþreifanleg vandamál, sem þarf að setja upp í fræðilegar rannsóknarspurningar, svo hægt sé að vinna með þau í akademískum rannsóknum. Þau geta þá til dæmis hentað sem lokaverkefni nemenda. Samstarfið við Vitvélastofnun er því mjög mikilvægt fyrir okkur hjá Mesher.”
Emil Harðarson
stofnandi Mesher

RÖGG

Þekkingarfyrirtækið Rögg framleiddi í samstarfi við Vitvélastofnun hugbúnað sem Landhelgisgæslan hefur um borð í þyrlu sinni og getur fundið staðsetningu fólks, sem er týnt á hálendi Íslands. Hugbúnaðurinn getur skilið milli lífs og dauða með því að stytta leitartíma og er sá eini sinnar tegundar í heiminum.

„Það hjálpaði okkur mikið að hafa aðgang að sérfræðingum Vitvélastofnunar. Við gátum borið undir þá víðtæk vandamál og fengið frá þeim nákvæmar tæknilegar lausnir. Sérsniðin algrím (e. algorithm) sem Vitvélastofnun þróaði fyrir okkur var hægt að setja beint inn í nýja vöru. Það gerði okkur kleift að bjóða upp á vöru sem er hvergi annars staðar til í heiminum.”
Baldvin Hansson,
hugbúnaðarhönnuður hjá Rögg

„Við bara smelltum á 'komdu í kaffi' hnappinn á síðunni og vorum komin á fund stuttu síðar hjá helstu gervigreindar-sérfræðingum Íslands.“

komdu í kaffi!

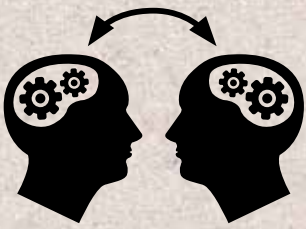
mint solutions

Mint Solutions framleiðir hátæknikerfi, sem kemur í veg fyrir lyfjamistök og notast meðal annars við tölvusjón til að greina lyf. Samstarf við Vitvélastofnun hefur opnað fyrir nýja möguleika á nýtingu gervigreindar í vörur og þjónustu fyrirtækisins.

„Þetta var mjög auðvelt. Við bara smelltum á „komdu í kaffi“ hnappinn á síðunni og vorum komin á fund stuttu síðar með helstu gervigreindarsérfræðingum Íslands. Þátttaka í Hátæknihraðbrautinni leiddi síðan til þess að Mint Solutions var boðið áframhaldandi samstarf með því að bætast í hóp þeirra sex fyrirtækja sem taka þátt í Hraðlinum.”
Áslaug Bjarnadóttir,
yfirmaður þróunar hjá Mint Solutions.

VISKU-BRUNNURINN

Vitvélastofnun nýtir frjálst flæði tækni, hugmynda og uppfinninga frá samstarfsaðilum úr fjölmörgum geirum til að auka verulega möguleika á tækniyfirfærslu milli fyrirtækja, háskóla og annarra stofnana án þess að slá af kröfum um upplýsingaöryggi.



Vitvélastofnun Íslands býður upp á einstakan viskubrunn þekkingar, sem styttir þróunartíma, sparar kostnað og opnar möguleika, sem annars hefðu legið ónýttir.

- Sama grunntækni nýtist á ólíkum sviðum.
- Samstarfsaðilar fá nánast undantekningarlaust jafnan aðgang að grunnrannsóknum, hagnýtum rannsóknum, tækni, fólki, verkefnum, og þekkingu á fjölda sviða.
- Gagnsær nýtingarréttur.
- Tæknin að miklu leyti ekki komin á samkeppnisstig (e. pre-competitive) og því kjörin til samnýtingar.
- Aldrei fleiri en einn samstarfsaðili á hverjum tímapunkti úr hverri atvinnugrein.

Starfi fyrirtækin á sama markaði geta samkeppnissjónarmið skert nýtingarmöguleika samstarfs. Oft nýtist tækni úr einum geira þó vel, eða jafnvel betur, í öðrum geira – *án samskipta milli geira leitar rétta tæknin ekki á réttan stað.*

Vitvélastofnun er ekki samkeppnisaðili og vinnur ekki samtímis með fyrirtækjum sem starfa á sama markaði. Markmið stofnunarinnar er að styðja við og auka viðtæka hagnýtingu þekkingar á ólíkum sviðum og ýta þannig undir hagkvæmni og aukna verðmætasköpun í samfélaginu.

SÉRÞEKKING VITVÉLASTOFNUNAR (IIIM) OG GERVIGREINDARSETURS HR (CADIA)

Software Development	Data / Big Data	Artificial Intelligence	Simluation & Modeling	Complex Systems
• Algorithmic / software design • Distributed systems • Model implementation • Code deployment and application • Scaling • Control systems • Information architectures • Semantic Web • Software networks • Virtual environments • Augmented realities • Large software architectures • Automation	• Information governance • Data management • Regression • Multivariate correlation • Multi-hypothesis testing • Data analysis & integration • Databases • Classification • Crypto-currency • Fine-grained parallelization • Map reduce / Hadoop / etc.	• Computer vision • Graphical agents and social AI • Reinforcement learning • Reasoning & logic systems • Artificial neural networks • Deep learning • Deterministic & probabilistic neural networks • Data mining • Artificial general intelligence • Autonomous agents • Speech recognition • Natural language processing	• Agent-based simulation & modeling • Multiscale integrative models • Biomedical / Biophysical Modeling • Banking • Cardiovascular modeling • Computational fluid dynamics • Numerical methods • Agent-based modeling & simulation • Cellular automata	• Realtime systems • Finance / forensic finance • Financial / economic analysis • Software audit • Macro-economics • Microfluidics • Networks • Cardiovascular diseases • Human physiology • Fluid-structure interactions

VITVÉLASTOFNUN ÍSLANDS SES

Vitvélastofnun Íslands ses er sjálfseignarstofnun með það markmið að brúa bilið á milli iðnaðar og háskólarannsókna og að hraða nýsköpun í hátækniiðnaði á Íslandi. Náið samstarf stofnunarinnar við Tölvunarfræðideild Háskólans í Reykjavík tryggir tengsl við fremstu vísindamenn landsins á helstu tæknisviðum, svo sem stærðfræði, fræðilegri tölvunarfræði, verkfræði og gervigreind.

Rannsóknir Vitvélastofnunar eru að miklu leyti knúnar áfram af þörfum iðnaðarins og niðurstöðurnar hafa nýtingarmöguleika á mörgum sviðum eins og framleiðslu, tölvuleikjum, þjálfun með aðstoð tölvutækni, lífupplýsingafræði, orkukerfi og stjórn vélmenna.

Vitvélastofnun leggur áherslu á að bæta gæði hugmynda og auka samskipti og flæði upplýsinga milli samstarfsaðila sinna. Markmiðið er að flýta fyrir árangri og hjálpa fyrirtækjum að sjá lengra inn í framtíðina, breikka sjóndeildarhringinn og auka möguleika þeirra á að koma hátæknivörum fyrr á markað.

IIIM THE ICELANDIC INSTITUTE FOR INTELLIGENT MACHINES

The Icelandic Institute for Intelligent Machines (IIIM) is a nonprofit research institute that catalyzes innovation through a focused exchange of ideas, people, projects, and intellectual property. Through close affiliation with Iceland's strongest technological academic department, Reykjavik's School of Computer Science, we bridge the gap between industrial engineering needs and academic research results.

Our work is driven by the needs of industry, and has relevance to a wide range of application areas. To name just a few: Computer-based training, bioinformatics, computer games, energy system, virtual and augmented realities, robotics, artificial intelligence, machine learning, and data manipulation, IIIM's software tools, methods, and systems help companies see further into the future, bring high technology to their product lines, and produces more advanced products faster.

CONTACT

IIIM is located on the 2nd floor of Reykjavik University's new Millennium building in Nautholsvik, within unique outdoor areas and near the country's only artificial beach.

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IIIM

IPKE WACHSMUTH, BIELEFELD UNIVERSITY

Dr. Ipke Wachsmuth, on IIIM's Advisory Board since 2009, is emeritus professor of Artificial Intelligence and former director of the Center for Interdisciplinary Research (ZiF) at Bielefeld University, Germany. Also a former president of the German Cognitive Science Society, Dr. Wachsmuth has a strong multidisciplinary commitment, reflected in many research papers published in areas related to the understanding and modeling of human behavior as well as the exploitation thereof in intelligent systems. Since the 1990s, Wachsmuth has been a driving force behind the Interdisciplinary College, an annual spring school in the fields of neurobiology, neural computation, cognitive science, artificial intelligence, robotics and philosophy. A major part of his recent research was conducted in the Collaborative Research Center "Alignment in Communication" and the Center of Excellence "Cognitive Interaction Technology" (CITEC) at Bielefeld University.

CHALLENGES AND BENEFITS OF INTERDISCIPLINARY RESEARCH AND COLLABORATION - A REPORT FROM GERMANY

Scientific research today is marked by a growing differentiation and specialization in the disciplines. A discipline is characterized by the questions it wants to answer, and the methods it employs to look for such answers. Increased specialization means an inevitable narrowing of focus, which is indeed its main goal. But a narrower focus may also lead to narrow-mindedness. For science, this may have catastrophic effects. In the best case, a slow-down in the advancement of the frontiers of knowledge. In the worst case, a permanent blockage of cures for deadly diseases or better ways of preventing the devastating effects of natural disasters.

When different disciplines look at similar questions, it is often advantageous to learn from answers found in other disciplines by considering their methods, by "looking through their spectacles." With many "spectacles" or perspectives, a more complete picture is obtained through interdisciplinary research and collaboration.

But collaboration takes time and energy. Why would anyone want to complicate things when we already have perfectly-formed departments, each optimized to answer a certain set of questions? In spite of the seemingly well-organized chapters of textbooks, reality is complex and intricate and not arranged cleanly along the lines of already established disciplines, most of which have emerged by historical coincidence. Even more importantly, many research problems simply cannot be solved from a single disciplinary perspective, demanding a collaboration between the disciplines: *inter disciplinas*.

How can people be educated for interdisciplinarity? The Center for Interdisciplinary Research – ZiF – is an institute for advanced study which I directed for almost seven years. It was the seed institute for the founding of Bielefeld University in northwest Germany which, due to its historical origins, has a long tradition in interdisciplinary research. ZiF supports and houses interdisciplinary research projects from all fields across the natural and social sciences, engineering and the humanities. Its concept was developed by the German sociologist (and first director of ZiF) Helmut Schelsky who saw interdisciplinary exchange as a key driver of scientific progress. Being the oldest such institute in Germany, ZiF has been a model for numerous other similar centers in Europe.

As evidence for ZiF's attraction as a meeting place for interdisci-

The ZiF, Bielefeld University's Institute for Advanced Study, fosters outstanding and innovative interdisciplinary research projects. The ZiF is an independent thematically open research institution and is open to scholars from all disciplines and all countries.

plinary collaboration, more than a thousand scholars visit the center every year for colloquia and workshops, summer schools, and research groups with residential fellowships. ZiF research groups are the primary means of supporting long-term interdisciplinary collaboration. For several months, and sometimes for up to a year, the fellows reside at the ZiF and work together on a broader research theme.

One research group run in 2005/06 by my psychologist colleague Günther Knoblich and myself, a computer scientist, focused on 'Embodied communication in humans and machines'. At that time, embodiment had become one of the most promising theoretical perspective in the cognitive sciences and a challenge to research on intelligent machines. Yet the role of embodiment in communication (e.g., body stance, gesture, facial expression, voice quality) had still been granted comparably little attention, both in communication theories and in applied research on human-machine interaction. In order to look at these questions from the perspective of different disciplines, our group brought together international scholars from communication psychology, linguistics and psycholinguistics, theoretical biology and primatology, philosophy, computer science and robotics. While there was growing excitement for interdisciplinary engagement among the participants from the beginning, we soon realized that this was only a first step toward fruitful collaboration.

Interdisciplinary research and collaboration is not easy in practice – it requires extra steps and must be fostered and nurtured. But our experience shows that nothing else can take its place. Here is what we learned about the challenges and benefits of adopting an interdisciplinary approach.

"Interdisciplinary research and collaboration is not easy in practice – it requires extra steps and must be fostered and nurtured. But our experience shows that nothing else can take its place."

First of all, interdisciplinary projects need time. The incubation of the theme and its particular questions requires an extended period when, not subject to external influence, participants come to learn about each other's perspectives and insights. Typically, after initial excitement, there is confusion when participants realize that their understandings of terms appear to be different from their peers. Clarification and attempts at definition can encounter resistance and difficulties before change and widening of perspective follow.

“Temporary confusion is to be expected before findings produced through interdisciplinary research are mature enough to be presented to a wide audience.”

Second, there are many benefits, including those which are unexpected. Creativity is not plannable but fosterable by a change in perspective. In the diversity and richness of interdisciplinary exchange, it may happen that attention is drawn to new questions that haven´t been asked in one‘s field, and which henceforth inspire one‘s own research. Answers may even be found which were not sought after in the first place.

Third, the effects of interdisciplinary research and collaboration are gradual. Progress does not come about casually, and requires continued endeavor. Confusion and temporary disappointment are to be expected, before findings produced through interdisciplinary research are mature enough to be presented to a wider audience and dissemination of results can take place.

What else can be done to foster interdisciplinary research? Another notable and highly successful interdisciplinary activity in Germany is the Interdisciplinary College (Interdisziplinäres Kolleg, IK). Established in 1997 and located in the inspiring surroundings of Lake Möhnesee, the IK is an annual, intense one-week spring school, with a course program comprising science, technology, and humanities and including neurobiology, neural computation, cognitive science, artificial intelligence, robotics, and philosophy. It is aimed at students, postgraduates and researchers from academia and industry. Courses include introductions and methods courses (which allow participants to become familiar with the “spectacles” worn by researchers in other disciplines), as well as the in-depth treatment of a focal theme which changes from year to year. For instance, the theme of IK 2015 was ‘From Neuron to Person: Assembling Behavior and Cognition’, with a focus on how to analyze or design complete, autonomous agents – animals, humans, robots, and software characters. The benefits for participants of IK are multifaceted, and besides education for interdisciplinarity, it is a unique social event with ample chances for networking between academia and industry and for more continuous interdisciplinary collaboration.

A general observation is that the success of interdisciplinary research and collaboration does not result from individualistic perspectives but rather from interacting with one´s peers. It depends – over and above disciplinary qualification – on the willingness of participants to listen to each other, develop true interest in the others‘ perspectives, and to take on a new perspective to the end of a joint project. Any social or structural support that can be introduced to enhance smooth, appropriate, and enjoyable interaction between individuals and groups will help the research to move forward.

While interdisciplinary research and collaboration presents

NOTES
www.uni-bielefeld.de/ZIF/

www.uni-bielefeld.de/ZIF/FG/2005Communication/

www.interdisciplinary-college.de

challenges and calls for extra steps to be taken, the many benefits far outweigh this work, as nothing can really take the place of interdisciplinary research and collaboration for bringing ideas forward. So, get ready to change your perspective, change your concepts, give up positions, learn about the methods and the perspectives of others (to see "through their spectacles"). There is much to be gained. It is worth the effort.

IIIM AND CADIA'S AI FESTIVAL

IIIM and CADIA's annual AI Festival, Gervigreindarhátíðin, was held on October 2nd 2015, with over 120 attendees.

TERMINATOR AT THE DOOR: JUST HOW DANGEROUS IS AI?

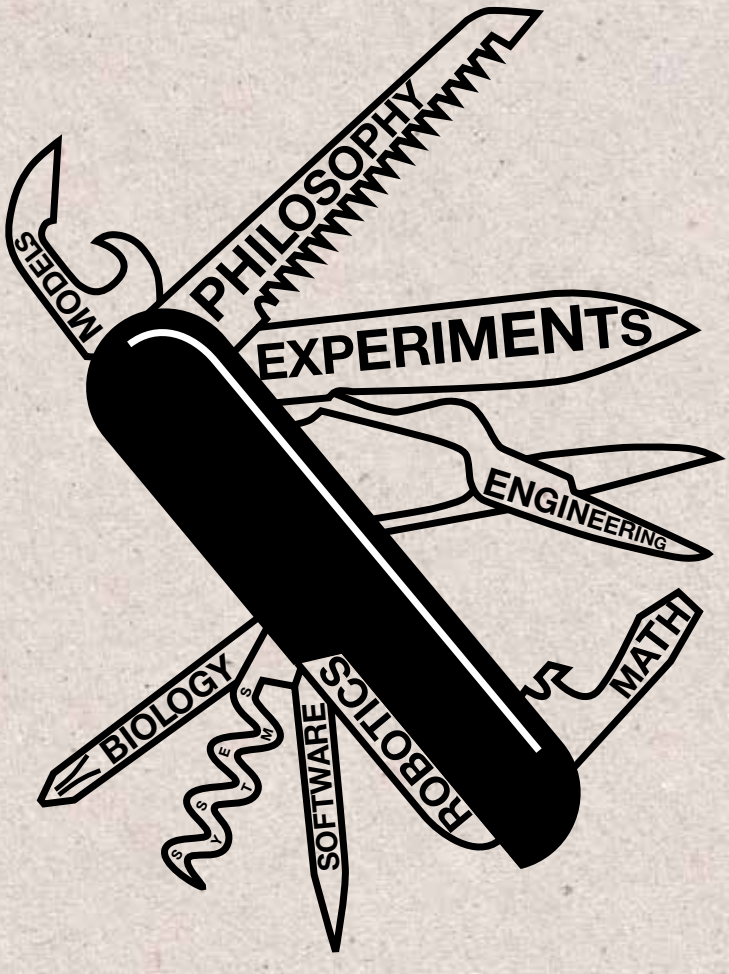
The aim of the AI Festival is to raise awareness of AI and high-tech companies among both the general public and industry players, and at the same time, to support the cluster of high-tech companies in Iceland.

Following IIIM's release of their Ethics Policy for peaceful R&D last year, the 2015 AI festival was devoted to the possible dangers that mankind faces from the use of artificial intelligence, in particular in today's military affairs.

The guest of honor was Mr. Noel Sharkey, a professor of AI and Robotics at the University of Sheffield. Dr. Sharkey has been very vocal about the threat of autonomous weapons and has written numerous articles and appeared on television as a spokesperson against the use of AI for military purposes. Sharkey chairs "The International Committee for Robot Arms Control", an NGO that is seeking an International treaty to prohibit the development and use of autonomous robot weapons - weapons that, once launched, can select human targets and kill them without human intervention.

Other speakers were Salvör Nordal, Director of the Centre for Ethics at the University of Iceland, as well as IIIM's Founding Director Dr. Kristinn R. Thórisson and CADIA's speaker Hannes Högni Vilhjálmsson, associate Professor at RU's School of Computer Science. After the lectures there was a lively panel on the ethics of AI, moderated by philosopher Thorbjörn Kristjánsson.

The following poster and demo session offered attendees refreshments and the opportunity to have a glimpse at some of the most advanced products, services and research in the field of AI, automation, and high-tech in Iceland. The guests had a chance to experiencee a walk in a virtual reality, play games, learn about how to race a robot and how AI technology can be used in various sectors such as in the hospital environment and online retail sails, just to name a few applications.



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