Report of our kick-off meeting, Aarhus, October 9th, 2019

Anna Jia Gander

Introduction

We want to create a citizen science serious game in the field of quantum physics using hybrid intelligence. The game we are studying is Quantum Moves 2 which is developed at the Center for Hybrid Intelligence and ScienceAtHome in Aarhus University of Denmark. In our project, we will use games to explore and compare the strengths and weaknesses of human and artificial intelligence and develop optimal interactions between the two. We believe that the process of developing engaging interfaces that allow experts and citizen scientists alike to view complex research problems from different angles may contain the key to developing future hybrid intelligence systems in which we make optimal use of human creativity.

Background: using citizen science as a tool to develop hybrid intelligence system

In recent decade, many scientists had made great efforts towards the goal of developing artificial intelligence and hybrid intelligence systems. For example, a quest as ambitious as building a quantum computer has interested many scientists over the decades. Although there has been great progress, many challenges yet remained. Complex issues such as the quantum optimal control have been identified as that scientists and computers of today cannot solve. Why not gamify these complicated problems and ask players all around the world to help? Because citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding of the given problem, citizen science projects may help develop hybrid intelligence systems. Here, citizens act as contributors, collaborators or as project leaders and have a meaningful role in the project, for example, in executing tasks like collecting images and making ratings that generate data for supervised machine learning. These work practices performed by citizens as a broad and open mass of participants characterize crowd intelligence, which can help train, supervise, and supplement machine intelligence. Also, machine intelligence or algorithmic automation can make the crowd more efficient, skilled, and accurate in carrying out their complex tasks. This human-machine interaction and its generated algorithmic actions can have great impact on people's lives. We can study this interaction and its social and technical impact by means of behavioral experiments using crowdsourcing platforms. The co-evolving learning abilities of human and machine in this interaction can be investigated in crowdsourcing. This is how we posit our project in the area of citizen science.

Event: project kick-off meeting on 8th of Oct 2019

With this joint goal to bridge citizen science and hybrid intelligence, we joined our project partner and had our kick-off meeting on 8th Oct at the Department of Physics and Astronomy of Aarhus University in Denmark.

Aims and objectives

Our aims and objectives include:

1. Learning about the expertise that the GU team can provide

2. Getting up to speed with latest developments of QM2
3. Deciding the role of the GU partners in the broader project on hybrid intelligence and citizen science
4. Confirm team membership
5. Plan next steps
6. Identify challenges to goals

Meeting participants

There were ten scientific researchers participated in the meeting, including Denmark – Dr. Jacob Sherson, Janet Frances Rafner, Shaeema Zaman Ahmed, Jesper Hasseriis Mohr Jensen, Dr. Carlos Mauricio Castano Diaz, Kasper Krog Andersen, Bosco Taddei, Dr. Miroslav Gajdacz and Sweden – Dr. Marisa Ponti and Dr. Anna Jia Gander. The core team members for our project partner work between the University of Gothenburg and the Center for Hybrid Intelligence and ScienceAtHome are Dr. Jacob Sherson, Dr. Marisa Ponti, Janet Frances Rafner, Dr. Miroslav Gajdacz and Dr. Anna Jia Gander.

We are a diverse team of scientists, physicists, citizen scientists, learning scientists, sociologists, linguists, game developers, designers and visual artists. We have varied research background with complementary research methods and theoretical frameworks. We got excited!

Morning session: introduction and alignment

Dr. Jacob Sherson presented a keynote introduction to the core team members and addressed the meeting motivation and scope. Dr. Marisa Ponti and me made introduction presentations respectively, with focuses on our relevant previous research work and methodologies that we have employed. Dr. Miroslav Gajdacz gave a presentation on the latest development of Quantum Moves 2 and the analysis results.

With aligned information, we started to discuss how we envision our project on using citizen science for developing hybrid intelligence systems by at first studying the game Quantum Moves 2. We used brainstorming to generate ideas and concerns.

First, we defined the key concepts.

We agreed to go along the definition of hybrid intelligence proposed by Dellermann et al. (2019), which refers to the ability to achieve complex goals by combining human and artificial intelligence, thereby reaching superior results to those each of them could have accomplished separately, and continuously improve by learning from each other. Human computation is regarded closely related to the efforts on hybrid intelligence, though differs in the emphasis on the interactive learning process between humans and machines. According to Law and von Ahn (2009) and Qinn and Bederson (2011), human computation refers to the paradigm for utilizing human processing power to perform tasks or solve problems that computers cannot yet perform or solve, usually in an enjoyable manner.

Second, we decided to use citizen science for investigating hybrid intelligence.

As agreed within our group, crowdsourcing platforms (e.g., QM2) are the best place to study hybrid intelligence, for they provide easy access to human intelligence on demand in a scalable and versatile way. For example, the players' decisions about when and where to make their moves in the game and to start and stop the optimization algorithm can introduce high-level heuristics and human intuition to the conventional algorithms. In this workflow, human intuition and conventional optimization are working in tandem to produce high-quality solutions to complex science problems. The project can inform us about the strengths of human intelligence and the challenges about accessing human intelligence, and can provide implications of how to quantify human intelligence and generate superior hybrid intelligence with help of the machine intelligent optimization.

Afternoon session: introduction and alignment

After a nice coffee and lunch break, the core team members Dr. Jacob Sherson, Dr. Marisa Ponti, Janet Frances Rafner, Dr. Miroslav Gajdacz and Dr. Anna Jia Gander continued to set expectations and goals for the project with an objective to identify *the partner roles* and *the first collaboration steps*.

First, we discussed theorizing computational citizen science.

Dr. Jacob Sherson and Janet Frances Rafner presented their idea of developing a new framework for citizen science research in general and characterizing computational citizen science in particular. Issues that interest us include but not limit to how citizens, scientists, and algorithmic automation systems co-create their interaction, learning processes, methods, outcomes, thinking patterns, adaptation, engagement, knowledge transformation, life-learning beyond the participation in the project, mathematically defined challenges, and subjective and objective assessments of the task performance. We will make an anthropological and ethnographic study of all the methodologies that citizen science projects have so far engaged in. We aim at identifying the similar and distinct characteristics of computational citizen science, human computation, and hybrid intelligence. What we know now is that hybrid intelligence is broader than human computation that is broader than computational citizen science. Computational citizen science directly relates to two aspects (more to be identified) of human computation, motivation and intuition. We also know that dimensions of human computation (which emphasizes on complementary role of human intelligence in solving computational problems) are related to hybrid intelligence (which emphasizes on complementary roles of both human and artificial intelligence in solving computational problems and their co-evolving learning processes). What dimensions of human computation we shall focus on and how to relate and contribute to hybrid intelligence systems will be further investigated in our project.

Second, we looked at the currently developing tools for studying human-computer learning interactions.

Shaeema Zaman Ahmed joined us for this part and together with Dr. Miroslav Gajdacz presented their newly invented tools, Quantum Composer and SciNote, which are still under development. These tools are open educational resources and a kind of citizen science platforms, which are with an aim to be applied at a global setting. The participants in our project will be engaged in playing the game and delivering the data, but also beyond the game for

instance making observations of the game and working out solutions and instruction/guide for the game. The purpose is to have such a tool that is not domain specific (e.g., a particular context of a citizen science project) but adaptable to diverse contexts and projects to facilitate the qualitative (learning transformation) process that lies beyond the mathematical defined interactions and help us understand human heuristics. Such learning transformational activities are much different from just playing the game. Rather, these learning transformational activities can present deep interactions and reflections of playing the game, which include for instance genuine insights and knowledge about how they made certain solutions and why they made so. This will eventually give us deeper knowledge about the hybrid intelligence processes and enable us to compare algorithmic performance with human computation. In our project (through the game of Quantum Moves), we are more interested in understanding the humans' problem solving process than their solutions to the game challenges.

Third, we identified the first two tasks.

During the meeting, we exchanged our thoughts and identified two collaboration tasks to start with. First, we will make a comprehensive literature review of citizen science projects, investigating citizen and scientist involvement, participant's engagement, interaction mode, and project application etc. to make a global map of citizen science and to categorize citizen science. Second, we will use the finding of this theoretical work to guide or support the design of the aforementioned tools (i.e., Quantum Composer and SciNote) that are currently developing at the Center for Hybrid Intelligence and ScienceAtHome. We ended our kick-off meeting by playing the game Quantum Moves 2 together. We feel that we have had a nice start of our project!

References:

Dellermann, D., Ebel, P., Söllner, M., Leimeister, J. M. (2019). Hybrid Intelligence. *Business & Information Systems Engineering*, 61(5), 637-643. https://doi.org/10.1007/s12599-019-00595-2.

Law, E., & von Ahn, L. (2009). Input-agreement: a new mechanism for collecting data using human computation games. In *CHI '09 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1197-1206. https://doi.org/10.1145/1518701.1518881.

Qinn, A. J., & Bederson, B. B. (2011). Human computation: a survey and taxonomy of a growing field. In *CHI '11 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1403-1412. https://doi.org/10.1145/1978942.1979148.
