Global Brain Institute: Strategic Objectives and Activities

Introduction

The *Global Brain* can be defined as the distributed intelligence emerging from the ICT network that interconnects all people and machines on this planet [1]–[4]. The *Global Brain Institute*[1] (GBI) was founded in January 2012 at the *Vrije Universiteit Brussel* (VUB)[2] to research this phenomenon [5]. Its short-term aim was to set up a working team of researchers who would develop a mathematical model of the Global Brain. The intention was to show that such a complex and seemingly ill-defined subject can be analyzed in a precise, scientific manner.

Now that the team has developed a good working organization, and that the foundations of the mathematical model are solidly in place, it is time to define our longer-term ambitions, together with concrete strategies for reaching these objectives.

Objectives of the GBI

The GBI starts from the assumption that the distributed intelligence of the Internet is taking over ever more functions from individuals, organizations, and other technologies. It is becoming a "nervous system for the planet" [6], i.e. a network for the communication and processing of all information, and the coordination of all human and machine action. The result is a system of decision-making, problem-solving and governance that is increasingly *distributed*, harnessing the knowledge and capabilities of all people, databases and computers collectively. Such a global organization will radically change society, politics, the economy, technology, education, and daily life. It should spectacularly augment our capabilities for tackling global, local and personal challenges.

The fundamental aim of the GBI is to better understand these changes. This would help us to anticipate them and to direct them towards the most desirable outcomes—while as much as possible steering clear of dangers and negative side effects. By disseminating our insights and recommendations to scientists, decision-makers and the wider public, we hope to effectively influence these developments. In this way, the GBI intends to help the anticipated "Global Brain" organization of the world come about as efficiently as possible, maximizing its positive effects while minimizing any negative ones.

Such an ambitious undertaking requires a sufficiently large and dependable organization. Therefore, the GBI intends to become an internationally known and respected scientific institute, eventually employing dozens of highly qualified researchers from around the world. Some examples of comparable interdisciplinary institutes are the *Future of Humanity Institute*[3] in Oxford, the *New England Complex Systems Institute*[4] in Boston, and the *Institute for European Studies*[5] at the VUB. This will require obtaining additional grants and attracting more high-level scientists, students, collaborators and advisers.

Our approach for understanding and steering the emerging Global Brain rests on four pillars. The first pillar is the development of a *theoretical model* of how the ICT network self-organizes into an increasingly complex and intelligent system. The second pillar aims at *testing* that theory with the help of simulations, empirical data, and experiments. The third pillar aims at *applying* these insights

[1] http://globalbraininstitute.org
[2] http://www.vub.ac.be/en/
[3] http://www.fhi.ox.ac.uk/
[4] http://necsi.edu/
[5] http://www.ies.be/

to the real world, by sketching out likely future scenarios for the evolution of the Global Brain, and by proposing Global Brain inspired recommendations and designs for future education, ICT and governance. The fourth pillar promotes the wide *dissemination* of these ideas, by reaching out to different audiences via different means. Each of these broad "pillars" of our work can be subdivided in more specific objectives.

Attaining these objectives should result in a range of products or "deliverables" that we will make as much as possible freely accessible to everyone. These will typically be scientific publications or reports aimed at a professional or broader audience, but will also include software, courses, seminars, data, or recommendations. Each objective will be carried forward by specific people, some from within the GBI, others from collaborating institutions. One reason for the proposed subdivision in objectives is that this makes it easier to collaborate with specialized groups, who tend to have a more narrow focus. The following scheme will now sketch each of the four pillars and their specific objectives.

1. Theory

The first pillar aims at the development of an in-depth theoretical understanding of the Global Brain. This theory is built up in layers, from the most fundamental and abstract via increasingly detailed specifications to the most concrete and application-oriented.

1.1 A formal theory of the self-organization of distributed intelligence

The foundation for all our theoretical models is a transdisciplinary theory of how distributed intelligence can self-organize out of the interactions between initially independent agents. This represents the general dynamics of a *complex adaptive system* [7], [8], such as an ecosystem, a society, or the human brain. Agents should be conceived abstractly, as any component of the system that acts in response to the conditions it senses. By adapting to each other's actions, agents eventually learn to coordinate their actions. This helps them to maximize synergy and minimize conflict or friction [9], [10]. The resulting system of coordinated actions exhibits intelligence, in the sense that it "knows" how to adapt to a variety of conditions, and thus solve the problems it is confronted with. The basis of this theory [10], [11] has already been formulated in the *Evolution, Complexity and Cognition group* (ECCO), the research group out of which the GBI arose.

This theory will be developed further—conceptually as well as mathematically. A promising approach for a mathematical foundation is *Chemical Organization Theory* [12], [13]. This is an abstract formalism that describes how networks of reactions between reactants (termed "molecules") can produce "closed" and "self-maintaining" subnetworks (termed "organizations"). Agents in this framework correspond to catalysts, i.e. reactants necessary for a reaction to occur, but which are not themselves affected by the reaction. Organizations then play the role of higher-order agents. Various algebraic and topological methods can be used to analyze the network of reactions, and thus formulate the necessary and sufficient conditions for self-organization to occur.

1.2 A conceptual model of the Global Brain

The next level of our theory is an application of this abstract conceptualization to the concrete system formed by our ICT-supported global society. Here, agents represent individual people, organizations, or computer systems. The Internet-supported links between these agents determine which interactions (or "reactions") can take place. The equivalent of the "reactants" necessary to start a reaction are called "challenges". A challenge is a piece of information (e.g. an email message, or a Facebook post) about the present situation that carries potential value for the agent that receives it [14]. Positive values represent opportunities to gain some benefit; negative values represent problems that threaten with a loss. Thus, challenges stimulate agents to act, by "processing" the

challenge in order to acquire the gain and/or avoid the loss. Agents interact with other agents by selectively passing on challenges to each other along the links in their network. Thus, challenges *propagate* across the global network, while being processed collectively by the individuals that encounter them [15]. This is similar to the spreading activation that characterizes the neural networks in the human brain.

1.3 A mathematical model of the Global Brain

This is a formalization of the previous conceptual model so as to allow a precise, quantitative representation [16]. Situations, challenges and agents' needs are represented as points in an *N*-dimensional vector space. The vector components (real numbers) represent potential positive or negative values. Agents and situations are located on vertices in a weighted, directed graph. An agent processes a challenge by multiplying the corresponding vector with its matrix, which represents its processing skills. This process in general "relaxes" the challenge, by reducing the absolute value of its components proportionally to the amount of benefit the agent extracts. Both needs and skills are different for different agents, so as to represent individual differences. Interactions between agents are represented by the transmission of challenge vectors along links in the network. Links change their weights according to a reinforcement-learning rule. The model defines several quantitative measures for the effectivity of both individuals and network. These include: agent fitness, intelligence, social capital, reputation, mood, and overall distributed intelligence.

1.4 A simulation model of the Global Brain

This is a computer implementation of the mathematical model. The basis is a multi-agent software framework running on a large graph database that represents the network along which challenges are propagated. Our prototype simulation environment, called *ChallProp* [17], and its successors will all be made available to the scientific community for free use and development as an open-source project. The framework is modular, including a variety of components and processes that can be switched on or switched off, depending on parameter values. This makes it easy to add new modules when we want to simulate additional properties or processes, without drowning in complexity. The simulation should in principle be able to deal with millions of agents, links and challenges, thus providing a relatively realistic model of self-organization processes on the Internet.

2. Experiments and Tests

A good theory should be able to predict real-world phenomena. This can be tested by comparing the implications of our conceptual model or the results of our simulation with observations. The second pillar of our approach is thus aimed at validating the theoretical ideas developed in the first pillar by confronting them with reality.

2.1 Computational experiments

By varying its parameters and components, the simulation allows us to explore a wide variety of scenarios for social self-organization [7]. These include the spread of memes, the self-organization of a market, the effect of technological innovation, and the dynamics of social networks. The test of the theory is whether it can qualitatively reproduce known social phenomena, such as the clustered, scale-free topology of social networks, the logistic dynamics of information spreading, or the law of supply and demand governing market interactions. Results that do not agree with generally accepted knowledge would point us towards questionable assumptions in the model, thus helping us to improve conceptualization, formalization or implementation. Positive results would confirm the broad validity of the theory.

2.2 Predicting empirical data

A second type of test is more concrete, as it uses the model to reproduce quantitative data from a real-world situation. An earlier version of the simulation model already managed to reproduce the results of several classic experiments in social psychology [18]. The new simulation should, for example, be able to statistically forecast the propagation of posts in an existing social network, such as *Facebook* or *Twitter*. To achieve this, adequate data must be gathered and converted to a format compatible with the model. For example, profiles of people and the texts they post can be converted to vectors (lists of numbers) using *Latent Semantic Indexing* or a similar technique. The propagation of these vectors across our simulated agent network should then be significantly correlated with the propagation of posts in the real social network. A lack of correlation would indicate erroneous assumptions in the theory, helping us to correct the model. In case of a weak correlation, we should be able to improve the precision of the forecast—and thus fine-tune the model—by adjusting its parameters.

2.3 Social experiments

The ultimate test of a theory is whether it can predict phenomena that have not yet been observed in reality. By exploring the conceptual model and the simulation, we may develop plausible scenarios for what would happen in particular, as yet untested, circumstances. We can then recreate these circumstances in an experiment with real people, for example by letting them interact across a computer system according to the rules we have specified. (We could e.g. change the propagation rules in the Synthetron system for group negotiation [19], [20]). If their behavior would evolve in a way similar to the one of the simulation, we would get another powerful confirmation of the validity of our theory. There exists a variety of methodologies for such social experiments, e.g. in the domains of social psychology [18], collective intelligence [21], [22], behavioral economics, and "living labs". Here too, deviations between simulated and actual results will allow us to correct inaccurate assumptions and thus improve the model.

3. Applications

A good theory should not only make predictions for controlled, experimental situations, but for developments in the real world. Such predictions would help us to determine which interventions would produce the highest social value, or which potential problems are most important to address. The theory of the Global Brain suggests a variety of processes and technologies that would improve the functioning of our highly complex society. Here we list a number of relatively direct applications of the theory.

3.1 The Interversity project

Probably the most direct step towards a globally distributed intelligence is the creation of a universal system for research, education and innovation—i.e. the creation, dissemination and application of knowledge. These are the functions that are normally performed by a university. However, universities at present are still centralized organizations with a relatively small number of researchers, professors and students residing in a particular location. Thanks to the Internet, these functions can now be organized globally—thus creating a universal, borderless network for the free exchange, pooling and improvement of knowledge.

Already in the 1930's, the author H.G. Wells proposed to develop such an institution, which he called a "World Brain" [23]. Yet, we had to wait for the Internet to make this practically feasible. Some important steps in that direction are Wikipedia, the global encyclopedia to which everyone can contribute, open access repositories and forums for research, and the burgeoning world of MOOCs (Massively Open Online Courses [24]).

We propose the concept of *Interversity* (*Inter*active, *Inter*net uni*versity*) as an emerging design that would integrate these and other technologies, communities, and institutions [11], [25]. Its core would be a self-organizing network of important ideas to which students, teachers and researchers from all over the world would contribute, thus developing an ever more complete, easy to learn, and up-to-date workspace encompassing the whole of human knowledge. The network would moreover stimulate budding entrepreneurs to apply these ideas in order to tackle concrete needs—e.g. by creating start-up companies, open-source communities, or NGOs to implement promising innovations.

3.2 Distributed governance

At present, decision-making power tends to be centralized in political leaders, governments, and the executives of multinational corporations. The GB paradigm suggests a more distributed, self-organizing system of governance, in which anybody who has a good idea, a minimum of experience, or the trust of others would be able to contribute to the collective decisions that need to be made. This would allow for a much more democratic and bottom-up approach to the problems that society faces, while producing more balanced, diverse and creative solutions [26]–[28]. Several methods and technologies have been proposed to achieve such collective intelligence or "wisdom of crowds" [29], [30]. Some of these have already proven to be successful in small-scale experiments. The GB model lays the foundations for a more integrated approach, while providing a simulation environment for testing out different approaches that would help us to select the most promising ones.

3.3 Designs for future ICT systems

Our theory of distributed intelligence should not only help us to design better methods of governance, but better technologies for supporting the processes of collective decision making and problem solving [26], [31]. Our simulation environment can investigate not only the effect of different forms of social organization or communication, but of different tools for processing and transmitting the accompanying information. This should allow us to converge on the most promising ones. One concrete application can be found in recommender systems. These use sophisticated algorithms to extract the collective wisdom of network users [31], [32], and use this to filter the nearly infinite number of options available on the Internet in order to select those that are most likely to help a particular individual or community.

3.4 Forecasting the future of ICT and society

To make effective decisions, it is important to have an idea of the challenges that the future holds in store. That demands that we develop plausible scenarios and forecasts for the most likely technological and societal developments over the following decades. The Global Brain theory, based on the self-organization of an increasingly powerful distributed intelligence, proposes a general dynamic for the emergence of new technologies, means of communication, and social institutions. Of course, society is much too complex to predict its development with any degree of certainty or detail. However, our GB theory should help us to conceive the most plausible scenarios [6], [33], while the simulation environment would allow us to quickly explore the effect of likely variations, unforeseen crises, or planned interventions on these developmental trajectories.

3.5 Consultancy

For individuals and organizations with specific issues, we will offer consultancy services, advising them on their concrete problems or questions. For example, given our understanding of the development of distributed intelligence, we may tell them why their present approach is not successful, or warn them about important changes to be expected in their area. For well-defined questions, we can use our simulation environment to represent the client's situation, and thus explore

the effect of different interventions or strategies in order to find the most effective ones. We will summarize our recommendations in the form of a report, tailor-made for the client's needs. For such services to commercial and governmental organizations, we will demand an appropriate fee, in order to recoup the personnel costs and support the further growth of the institute.

4. Dissemination

The fourth and last "pillar" of the GBI mission is to widely publicize and disseminate the insights we develop—so as to help researchers, decision makers and the general public to better understand the momentous changes that ICT is imposing on our social organization. Depending on the audience, we will make use of different means and media, so as to maximize the intended impact.

4.1 Publications

The most traditional method to disseminate scientific theories and results is the publication of papers in technical journals, proceedings, and edited collections. For our most important results, we will aim for journals with a high impact, such as *Nature* or *Science*. In addition, we plan to publish articles in less specialized journals and magazines, such as *Scientific American*, and in outlets for a broad audience, such as newspapers or blogs. A more extensive overview of our results will be published in book format—ideally one book directed at an academic audience that surveys the technical details of our models, complemented by a second, more easy-to-read book that explains the main ideas to the general public. For all our publications, we will strive to make them freely accessible through the Internet, e.g. through preprint archives and our website.

4.2 Education and training

We plan to develop a course on the future of the Internet for undergraduate students. This should give them a solid grasp of the concept of the Global Brain and the underlying technological and social systems and their evolution. While initially taught at the VUB, the content of the course will be made freely available over the Internet. In addition, we will continue to organize shorter workshops and seminars for more specific target groups, such as graduate students, decision-makers, or scientists from different backgrounds.

4.3 Media presence and community building

We are developing an integrated strategy for disseminating our results via the different electronic media. This includes our institute website[6], Facebook page[7], Twitter account, YouTube channel[8], blogs, open source software repository[9], mailing lists and forums. The website provides all the results of our work, in the form of publications, reports, videos, glossaries, software, or lists of Frequently Asked Questions, together with general information about our Institute. The more transient media, like Twitter or forums, will be used to distribute shorter pieces of news, questions or ideas, but if possible with a link back to a more in-depth report.

In this way, we hope to build up a growing community of people interested in our work on the Global Brain. These "followers" are likely to pass on interesting bits and snippets to others, thus broadening the community, while gradually developing a deeper understanding of the underlying theory themselves. From past experience, we expect that the most motivated of these community

[6] http://globalbraininstitute.org
[7] https://www.facebook.com/GlobalBrainInstitute
[8] http://www.youtube.com/user/GlobalBrainInstitute
[9] https://bitbucket.org/gbi/

members will become GBI volunteers, ready to help us achieve our various objectives or to apply to join our institute as graduate students.

4.4 Networking and cooperation

Another way of extending the group of people contributing to our broad aims is to establish contacts and collaborations with interested parties in the academic, business and government domains. In addition to our general publication strategy, this can be achieved by meeting with potentially interested people, presenting our work at conferences, and inviting potential partners to visit our institute. We will further build on our existing network of contacts and colleagues to get in touch with further people that have relevant abilities or interests. This should allow us to develop strategic collaborations with organizations that have complementary capabilities, thus strengthening our ability to tackle ambitious project. The resulting network will further facilitate the diffusion of Global Brain related ideas into high-level communities. Some examples of communities that we already are involved in are the *FuturICT* research network[10], and the network of *Global Agenda Councils*[11] of the *World Economic Forum*[12].

At a later stage, we plan to organize an international conference on the Global Brain, inviting participants from these different communities in order to initiate a worldwide discussion of the fundamental issue. This should further enhance the visibility of the GBI and the Global Brain concept.

Conclusion

We have sketched the different projects in which the Global Brain Institute is active or plans to become active soon. The overall plan of developing, modeling, simulating, testing, applying and disseminating a comprehensive theory of the emerging Global Brain organization of the world is without doubt very ambitious. Yet, for most of the objectives we have a solid foundation in work performed earlier—in part before the official creation of the Institute. The list of references at the end of this report provides a selective bibliography of these results.

To further make the project more realistic, we will try to find appropriate partners or collaborators who have the necessary expertise and interest to help us with each of our objectives. We hereby invite interested people or institutions to join our efforts. We will also be looking for additional sources of funding that would allow us to employ more researchers to work on our projects. In return, we will make the results of our research publicly available to any interested party, or provide private services to specific sponsors. In this way, we hope to grow into an internationally influential research institute that will help the on-going transition towards a globally distributed intelligence become a reality, and this as smoothly as possible.

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[10] http://www.futurict.eu/
[11] http://www.weforum.org/community/global-agenda-councils
[12] http://www.weforum.org/

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