CO-245

THE ICA RESEARCH AGENDA: REVIEW AND COMMENTS

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ABSTRACT

After several years of work, the ICA has published its Research Agenda on Cartography and GI Science. This paper will broadly review the structure and content of the ICA Research Agenda in terms of the keywords utilized and concepts linked to them, while recognizing the history and development of the ICA. Attention will then turn to the additional insights that might be gained by the use of Self Organizing Maps (SOM) of scientific terms used in papers presented at the ICC meetings. These form a "Term Dominance Landscape" of research clusters for those scientific papers. Attention then turns to expanding some important concepts in the ICA Strategic Plan dealing with Real and Virtual Maps, and then Deep and Surface Structure. The discussion then leads to the possibility of the ICA developing a Body of Knowledge for the field of Cartography, a timely opportunity for the ICA. Recommendations then follow from this discussion.

Keywords: ICA Research Agenda, Analytical Cartography, Body of Knowledge, Cartographic Ontology and Terminology, Role of Cartography & Geodata

INTRODUCTION

During the 1990s the ICA Executive Committee began to consider the development of a Research Agenda for the ICA organization. With the approval of the ICA Strategic Plan by the ICA General Assembly in Durban, South Africa (ICA,2003), a major effort was energized in 2003 to develop the ICA Research Agenda. Many efforts were made by the Executive Committee to develop the Agenda at their sessions, at the subsequent ICC meetings, with information analysis, and by circulating drafts. As part of the development process, the Agenda was reviewed by ICA Commission Chairs, and discussions were held at several ICC Conferences. The Agenda was finalized at the 2007 ICC Moscow meetings, where it was included in the proceedings. The published ICA Research Agenda (Virrantaus, Fairbairn, and Kraak, 2009) recognizes the rising importance of Geographic Information Science (GISci) and its important relationships to Cartography when it says:

"The ICA.....has a special position and role as a promoter of the development of cartography and GI Science. Research and development in the ICA aim in general to create theory and methods for cartography and GI handling. By applying theories and methods in various fields, new tools can be created for cartographic and GI practice."

Hence the document is titled "ICA Research Agenda for Cartography and GI Science", and works to weave ideas from both areas into the fabric of the document, which recognizes the growing linkages between the two fields. The Agenda is a good first step forward for the ICA. The discussion here is intended to enhance and extend this effort so it can be even more helpful to further the goals of the ICA.

THE RESEARCH AGENDA

The Research Agenda is mostly derived from the work of ICA Commissions and Working Groups, in consultation with them. These ideas have been expressed in terms of ten primary Keywords which appear to be framed in the discussion as applied research problems to be solved:

* Geographic Information;
* Metadata and SDIs;
* Geospatial Analysis and Modelling;
* Usability;
* Geovisualization, visual analytics;
* Map Production:
* Cartographic Theory;
* History of Cartography and GI Science;
* Education;
* Society.

These keywords come mostly from the various tasks found in the Terms of Reference of the various ICA Commissions and Working Groups. As the tasks surrounding the various key words are discussed, then

related concepts and theory are included to support those tasks. According to the Agenda,(Virrantaus, Fairbairn and Kraak,2009, p. 63) "The goal of this agenda is primarily to give some guidelines for the Commissions' work as well to lead to tighter cooperation between the Commissions." It also speaks of a higher goal: "More widely, the agenda is written in order to show the ICA's actual and potential contribution to scientific research within our global society." Then it says that the "ICA must have a clear agenda for research covering all fields and topics under the title Cartography and GI Science. This agenda, therefore, documents current research activity in these fields, suggests areas where more intensive or renewed effort is required....". These are lofty goals indeed.

When one examines the list of Keywords, or what can be seen as clusters of research topics, the text says that "The Keywords have been extracted from the mind maps produced in the brainstorming sessions referred above". This confirms that these topics have emerged from discussions of the ICA Executive in discussions with the Chairs of the various ICA Commissions and Working Groups. This then was used to produce the 10 Keyword clusters of research topics. Using this approach, The ICA leadership is emphasizing the use of the full range of theory and concepts in the 10 topic clusters, which are really applied research problems to be analyzed and solved. One can see that these 10 topics, and the theory and concepts associated with them, serve all three of the major paradigms of the field of Cartography: the Communication Paradigm, the Analytical Paradigm, and the Map Production Paradigm. It is expected that the various kinds of research conducted in the ICA community would be associated with the particular Paradigm with which it best operates. In a sense, each of the Paradigms is associated with a range of these 10 topics and their subcomponents. But what is really necessary here is to work to expand the depth and scope of the concepts and theory that underlies the field of Cartography as characterized by these Paradigms. Because of the historical development of the field, the concepts and theory in the areas of perception and communication, and map production (e.g. map projections) have had a longer time to develop. Hence there is a need to recognize the need to expand the concepts in the analytical part of the field as recommended by Moellering (2001). This is essentially an effort to catch up with the development in other parts of the field, and to recognize the usefulness and importance of them.

In the REFLECTION section in the Agenda, there are comments that: "the technology push is stronger than ever and new hypes pass every few months. However, some hypes prove to be of structural importance, so even when an hype some attention is required. An example is Google Earth/Maps type of developments." This is because technology fluctuates much quicker than theory and concepts. Tobler has estimated that the half-life of technique (technology) is three to five years, where the half-life of theory and concepts is 15-20 years. This is one reason why Tobler says that a field should lean more towards theory and concepts first, and technique (technology) second.

Further on in the REFLECTIONS section, there are concerns about where "users contribute to the collection of georeferenced materials via the web." in places like "wikis, blogs, photo sharing, podcasting, social software...,folksonomy and geotagging....". This is called Volunteered Geographic information, and the ICA Standards Commission will give a joint paper which presents a formal conceptual UML model of the SDI to include Volunteered Geographic Information (Cooper, et.al., 2011) at the coming ICC 2011 meetings in Paris.

LOOKING FOR RESEARCH CLUSTERS IN THE ICC PROCEEDINGS PAPERS

It is interesting to see what kinds of research clusters arise when one takes the approach of Skupin and de Jongh (2005) to analyze all the papers presented by individual researchers at the ICC meetings, and then develops a set of Self Organizing Maps (SOM) of the ICC papers topic landscape. They process the text files of the ICC papers from the CDs of these meetings, and then process the papers as an n-dimensional vector. They use various kinds of k-means clustering applied to the stemming, indexing and filtering of the text of all of the ICC papers to generate a two dimensional domain that Skupin and de Jongh call the "Term Dominance Landscape". In this space, they can then locate individual papers from that ICC meeting, and show their location in this topic landscape. They also take the terms from the individual papers and generates topic clusters which can be used to define topic polygons of topical interests.

With Skupin and de Jongh's Self Organizing Maps (SOM) of ICC papers, and the extracted and processed topics, one can glean some very interesting research relationships and dependencies. In their interpretation of the Term Dominance Landscape, Skupin and De Jongh note that two of the high level divisions of categories occurs between the term Data and the term Map. This result is very interesting in that the map is a graphic visualization, termed "Surface Structure", whereas the base data are non visual, and hence precede the map, are termed "Deep Structure" by Nyerges (1981, 1991). Maps are really visualizations that are transformations from the data domain, which are actually transformations between Real and Virtual maps (Moellering, 1980). An examination of this landscape, reveals that in the area of Data are also the

terms: metadata, user, interpolation, visual, test, level, and several others. In the area near the term Map, one sees the terms: transform, projection, subject, scale, sign, history, and variable. The relationships that emerge from this analysis of these ICC papers reflects many expected commonalities, but also show them, and many others, in a comprehensive way.

With Skupin and de Jongh's approach, one can compare and contrast the "nearness" of various topics with others, such as Map and Data. This approach enables one to begin to grasp the topical landscape of an entire ICC meeting, or in his case, the ICC 2001, Beijing, and 2003, Durban meetings together. Clearly, this analysis could also be conducted on the papers from more recent ICC meetings to produce these conceptual topic maps of the landscape of papers presented at those ICC meetings.

It seems that the ICA Executive can use the results of this kind of "topical landscape" research to analyze and more fully follow the research being reported by participants in the ICC meetings. This will provide an additional tool to understand the topical landscape of research being pursued by members of the ICA, in addition to the Commissions and WGs. Including this kind of analysis into the consideration and thinking to the ICA Executive Committee as they develop the Research Agenda, will provide them with additional powerful insights to more fully comprehend the various kinds of research clusters currently active in Members' ICA research projects.

EXPANDING THE CONCEPT OF THE MAP

The current ICA Strategic Plan in Section 3.2 Priorities for the Future, (ICA, 2003, p. 11) recognizes maps of many kinds and their associated concepts when it says:

"Although the concepts underlying cartography have always been much wider.... The creation of maps and mapping systems (real and virtual) remains a priority.....

Then it says:

...the new technologies have enhanced the power and potential of cartography (exploratory, analytical, and communicative) for a much wider community of both professionals and the general public.... Some, notably the researchers in analytical cartography (mathematical and analytical theory) and the developers of GISystem technologies, have exploited what have been referred to as the 'deep structure' (as opposed to 'surface structure') of cartography, to the enormous benefit of science and society. Many new cartographic products..."

Hence, it is useful to consider the broader conceptual definition of Cartography in terms of Real and Virtual maps, and the concepts of Deep and Surface Structure, as discussed by the ICA Strategic Plan. Slightly fuller definitions appear in the Appendix at the end of the Plan. The concept of real and virtual maps was first introduced into Cartography in the late 1970s (Moellering, 1980). A more recent discussion of the fundamentals of Deep/Surface Structure, and Real/Virtual Maps, was presented at the ICC Moscow meetings (Moellering, 2007). What follows is a very brief overview.

Real and Virtual Maps

From careful analysis of the various kinds of maps, two crucial and telling characteristics of maps emerge:

* Is the map product directly viewable as a spatial image? Yes/No;

* Is the map product hard copy? Yes/No.

From these two characteristics, a four-fold Linnaean classification of real and virtual maps can be developed as:

* Real Maps: Yes directly viewable; Yes hard copy - topographic sheets, globes thematic maps, 3-D solid surface carvings, block diagrams, etc.;

* Virtual Map Type I: Yes directly viewable; Not hard copy - CRT computer displays, video projector displays, virtual CAVEs, dynamic glasses, mental maps (2, 3-D cognitive images);

* Virtual map Type II: Not directly viewable; Yes hard copy - anaglyphs, gazetteers, stored holographic images, stored Fourier transforms, CD-ROMs, DVDs, etc.;

* Virtual Map Type III: Not directly viewable; Not hard copy - Digital Terrain Models, spatial databases, computer memory, magnetic tape, cartridges, cassettes, etc., and mental maps(itineraries, lists of directions, etc.) etc.

These four classes of Real and Virtual maps include all kinds of maps and map products, and hence the classification is exhaustive. All maps and map products fit into this general system of Real and Virtual maps because they all have these two characteristics. There are 16 Map Transformations that flow from these 4 R/V classes, which can be used to define, singly or in combination, any kind of processing of map information. It could be anything, ranging from a 3-D dynamic terrain model to a child reading a map, and everything in between. A few of the more important Real/Virtual Map Transformations can be seen as:

R/V Map Transformation Example

* R ==> R could be traditional hand drawn cartography;
* R ==> V1 could be a person reading a hard copy map;
* V1 ==> V1 could be a person reading a CRT display screen;
* R ==> V3 is the process of digitizing;
* V1 ==> R is making a CRT screen hard copy map;
* V3 ==> V1 is the CRT display of digital data from the PC memory;
* V1 ==> V3 is clicking a CRT screen menu bar as a command for the PS Computer Processing Unit <CPU>;
* V2 ==> V3 could be reading data from a CD-ROM into PC computer memory;
* V3 ==> V3 could be Tobler's mathematical coordinate transformations;
* V3 ==> V3 could be writing digital data from computer PC memory to a floppy disk, etc.
* V3 ==> V3 could be reading a digital data file from a Spatial Data Infrastructure network to a computer memory;
* V3 ==> V2 could be writing digital output to a CD-ROM, or printing digital output;
* V3 ==> R is digital generation of a hard copy map from a digital cartographic database.

Singly or in combination, these transformations can be used to define a very wide variety of spatial data and map transformations, from virtual map image generation and projection, to cartographic communication models. All of these transformations are conceptually independent of computer hardware. Their universality and flexibility are the very reason why they are vital to Cartography, and hence explicitly mentioned and referenced in the ICA Strategic Plan.

Deep and Surface Structure

The concept of Deep and Surface Structure in Cartography was originally developed by Nyerges (1981, 1991). This work is modeled on the work in transformational linguistics by Noam Chomsky which examined the linear linguistic syntactic patterns of written words and speech. Underneath this is the linguistic deep structure that deals with the semantics. Nyerges extended this concept into the 2-D, and 3-D spatial data domain with the concept of Deep and Surface Spatial Structure:

* Surface Structure: Spatially displayed geographic data; usually as a visualized map; can be the Real World itself. This is usually a Real map or Virtual map Type I.
* Deep Structure: The graphic and nongraphic attributes, relationships and interactions between spatial entities or objects. This is usually a Virtual map Type II or Virtual map Type III.

Nyerges' discovery and recognition of spatial deep structure has profound scientific and philosophical implications for the spatial sciences. In Cartography, it has helped to identify the "new half" or "second half" of the field of Cartography. This concept has applications in map reading, map visualization, and analytical cartography.

These two concepts are central to many concepts, models, and activities in Cartography. As conceptual perspectives, they provide much insight into the nature of the cartographic information and data that we process in many areas of the field. They are provided here as essential concepts for the field. They are two of the key concepts, along with many others, that form the conceptual basis for the field.

NEED TO SPECIFY A CARTOGRAPHIC BODY OF KNOWLEDGE

The Research Agenda, as noted in the quote on the first page above, says that "Research and development in the ICA aim in general to create theory and methods for cartography and GI handling." The field of Cartography already has a wide range of conceptual and theoretical knowledge in a broad set of areas. Some areas, such as map projections, map design and history of cartography have existed for centuries. Others, in a representative list, such as symbol design, data scaling, map perception, map generalization, cartographic communication, analytical cartography, geovisualization, Geographic Information, metadata and Spatial Data Infrastructures have arisen largely in the 20th century. Some in the latter part of this list are fairly recent conceptual areas. There are a host of additional particular conceptual areas associated with these larger areas. Many review articles have been written for most of the areas listed above. For example, Moellering (2000) has examined and discussed the range of concepts and theory within analytical cartography. In terms of expanding the conceptual theory, the ICA Standards Commission has published a formal conceptual UML model for the Spatial Data Infrastructure (SDI) (Hjelmager, et.al., 2008).

Hence, Cartography already has an implicit, although dispersed, Body of Knowledge in existence. This is not so clear to researchers like Fernández and Buchroithner (2009) where they say: "So far, cartography has experienced only little theoretical development", and then go on to say: "If cartography wants to reach

a wide-accepted more prominent scientific status, it needs, in addition to its well-developed and up-to-date methodology, to create its own epistemological basis." This situation needs to be addressed.

What needs to be done now is to create an explicit and organized Body of Knowledge which can encompass all of the theory and concepts in the full field of Cartography. This can be accomplished with the cooperation of ICA Executive and key researchers in all areas of the field. Such an undertaking would be a major effort, but the result would be organized and comprehensive enumerations of all parts of the body of knowledge that constitute the field of Cartography and its edge areas.

An Example Body of Knowledge from GI Science

The University Consortium for Geographical Information Science in the USA created and published a Body of Knowledge(BoK) for "Geographic Information Science & Technology", (GIS&T) (DiBiase, et.al. 2006). This comprehensive work was the result of efforts over more than a decade by many individuals in the field. Its primary sections are:

* Analytical Methods
* Conceptual Foundations
* Cartography and Visualization
* Design Aspects
* Data Mining
* Data Manipulation
* Geocomputation
* Geospatial Data
* GIS&T and Society
* Organizational and Institutional Aspects.

These 10 general areas cover the entire field of GIS&T, and are further broken down into 70+ subareas that are more specific, and are contained in the larger major areas. These subareas then in turn contain 300 detailed areas with specific and focused topics. They catalog every aspect of GIS&T, whether it be mathematical theory, computation, data modeling, or societal and organizational aspects of the field. DiBiase(2009) introduced this work to the ICA at the 2009 meetings in Moscow. Together, these topics form the basis of knowledge for the GIS&T field. It was reported by DiBiase that a BoK such as this must be updated frequently, especially in an evolving field. One can note that this work has been done from a North American perspective, and European views on geoinformatics may be somewhat different (Reinhardt, 2009).

Developing a Cartographic Body of Knowledge - A Challenge to the ICA

As discussed above, the field of Cartography has a wide and diverse body of knowledge that has been building over the last couple of centuries. Now is the time to bring together all of these diverse elements of the field as a conceptual and technical fusion that expresses both the depth and complexity of the field into a comprehensive and organized Body of Knowledge for the field of Cartography. Convening a body of subject matter experts, who thoroughly know their area of the field, to map out the fundamental organization would be the first step. Utilizing the current ICA Research Agenda, and any maps of the cartographic Topic Landscape of ICC research papers would also be very useful. With a concerted and effective effort, such a BoK for Cartography could probably be developed by the ICA in several years.

Such an intense effort would have great benefits for the field of Cartography. Firstly, it would have a well defined map of its conceptual and technical structure. All interested parties could refer to the Cartography BoK in order to understand the breadth and depth of the field at general and detailed conceptual levels. This would greatly improve the understanding of what constitutes the field, and perhaps how those concepts interact with each other. It could be used for discussions with national and international authorities so they could better understand the field, and how it is organized scientifically and technically. It would also have the great advantage that with the ICA, this BoK would be developed on a world-wide basis, unlike the UCGIS BoK for GIS&T that was developed from the perspective of a single country.

Not creating a BoK for Cartography would risk further fragmentation of the concepts and theory in the field. The UCGIS BoK for GIS&T in the USA defines Cartography rather narrowly and conventionally, and subsumes several cartographic concepts into other areas. So, if the ICA does not create a BoK for the field, the UCGIS BoK Cartography and Visualization section will probably become the default definition for Cartography in the USA. Since many countries follow scientific work in the USA, this narrow definition of Cartography may spread and be utilized more widely by other countries.

SUMMARY AND RECOMMENDATIONS

In retrospect it turns out that the ICA Research Agenda is an interesting piece of work that provides a good inward view of the research activities of the ICA Commissions and Working Groups. It seems to be oriented towards applied research problems, and brings in a lot of concepts that would be helpful to analyze those problems. In doing so, it presents an interesting view of the research efforts by the internal ICA Commissions and Working Groups. Comments in the REFLECTIONS section of the Research Agenda point out the rapid changes in technology, and imply the constantly changing nature of this kind of approach of cartographic research. Tobler's insight of the much longer half-life of theory, versus the much shorter half-life of technique (technology) really does help one understand this research instability. Hence, it is better to organize research around concepts and theory because this is the knowledge base for the field, and because it is much more stable. Then, the technology can fluctuate wildly, but the underlying cartographic and spatial concepts remain stable in the research over time.

One can also see the added advantage of including the "topical landscape" via Skupin and de Jongh's Self Organized Maps of the "Term Dominated Landscape" of the scientific papers presented at the ICC meetings. This will provide a valuable tool to the ICA Executive as they grapple with the research landscape of both the work of the Commissions and WGs, and then be able to include the "topical landscape" of the ICC scientific papers into their analysis and considerations.

Using the ICA Strategic Plan as an indicator, one can see that the broad understanding of Cartography is enhanced by the use of the concepts of Real/Virtual Maps, and Deep/Surface Structure. These are fundamental to the understanding of the field in all areas of work, and also in explaining the myriad of data processing and perceptual operations that take place in the field. These concepts should be should be utilized more widely to the benefit of the field.

Since Cartography already has an implicit, although dispersed, Body of Knowledge in existence it is in the interest of the ICA to initiate a project to develop a formal Body of knowledge for the field. This will systematically catalogue and organize this plethora of scientific concepts into a better and more organized structure.

Primary Recommendations to Enhance Research in the Field of Cartography

From the discussion in this paper, there are two primary Recommendations that emerge.

1) The ICA should analyze the topic/terms structures of scientific papers presented at the ICC meetings in the manner of Skupin and de Jongh to develop the "topical landscape" of research terms and topic embedded in that wealth of scientific papers. This will provide the ICA Executive a way to analyze and better understand the broad research landscape of research being by individual members of the cartographic community.

2) The ICA should move aggressively to bring together the implicit, although dispersed, concepts and theory in the field into an organized and systematic Body of Knowledge. The resulting BoK will initially be a great help to researchers inside the field itself, and to their students. Then it can be used to help professional and governmental organizations to understand the field of Cartography in all of its conceptual and technical

richness. Since this effort would be conducted under the auspices of the ICA on a world-wide basis, the BoK for Cartography will provide a resource that can be used throughout the world. This would benefit the field of Cartography throughout the world, and in individual countries, etc., as they work to understand Cartography as a field. This has implications for research, organizational, funding and personnel questions.

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