Detailed Curriculum Vitae

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1 Studies and Diplomas

I have studied in three fields.

1.1 Philosophy and Logic, University Lyon III and Paris I, France.

I started my university studies by a Deug (two years degree) in Philosophy at Lyon III University. Besides an introduction to the traditional fields of philosophy, the curriculum, said ”pluri-disciplinary”, included classes in History, Geography, Economics, Graphic Arts and Linguistics.

Interested in the double curriculum Logic-Philosophy proposed by the University Paris 1, I attended a ”second cycle” there, leading to a Licence (third year degree) in Philosophy as well as a Licence and a Maîtrise (fourth year degree) in Logic.

The two Licences included a common core made up of two classes in History of Sciences and Epistemology. In addition to these the licence of Logic included a class in Predicate Calculus and a class in Set Theory. The licence of Philosophy included a class in History of Philosophy.

The Maîtrise in Logic consisted of six classes: Language and Automata, Calculability and Informatics (including a programming class in Lisp and Prolog), Model Theory, Set Theory, Proof Theory, and Philosophy of Mathematics and Logic.

1.2 Mathematical Logic and Foundation of Informatics, Paris VII University.

I continued my studies by a ”third cycle” in Mathematical Logic and Foundation of Informatics at the University Paris VII. This cycle consisted in a DEA (fifth year degree) and a Doctorate (PhD). I will present my PhD in the Research Section below.

The DEA consisted of three terms. During the first one I deepened my knowledge of the material studied during the Maîtrise in Logic. During the second one, I followed two specialization courses in λ-calculus and Proof Theory. The lectures in Proof Theory were about several systems of sequent calculus, and in particular about normalization theorems for these systems. The second specialization course was about the different aspects of λ-calculus (syntax, typing systems, semantics, foundation of mathematics with Map Theory). The last term consisted of a research dissertation. My dissertation was about a foundational system of λ-calculus named Map Theory.

1.3 Computer Science

Besides the programming classes in Lisp, Prolog and ML which were parts of the Maîtrise and the DEA in Logic, I attended a professional training class as Unix Analyst during a period between my DEA and Doctorate when, without funding, I couldn’t start to work on my doctorate thesis. The training course was about Unix and Oracle (database) administration, C++ programming, analysis methods (Merise), operational research, and some basics about networks and protocols.

2 Research Experience

2.1 My PhD Thesis

My thesis is published as ENTCS Vol.**79** [51] and is about a foundational theory based on type-free λ-calculus due to Klaus Grue from the DIKU of Copenhagen, and named Map Theory. Notice that the λ-calculus is largely used in Computer Science and in particular in the study and design of functional programming languages. It is the consistent part of an original system designed by Church as a common foundation for both calculability and mathematics (foundation on the notions of function and application). Notice also that, on the basis of his theory, K. Grue built "Logiweb" which is a system for distribution of mathematical definitions, lemmas, and proofs over the Internet; it supports cooperation between researchers and allows formal verification of proofs that depend on definitions, lemmas, and other proofs that reside on different computers that are connected by the Internet.

Coming back to the original aim of Church when he created λ-calculus, Grue introduced Map Theory in [35] as a common foundation of both computer science and mathematics. This theory, referred here as MTF, allows in particular a thorough interpretation of predicate calculus and of $ZFC+FA$, where ZFC is the axiomatization of set theory of Zermelo-Fraenkel (without the well-foundation axiom), and FA is the usual well-foundation axiom. All primitive notions in logic and set theory (booleans, connectors, quantifiers, appartenance relation and set equality...) are translated into terms of the untyped λ-calculus enriched with few constants. Moreover, MTF gives a direct computational meaning to every usual set constructor (singleton, pair, power ...). It also contains an original induction scheme to define functions and an original induction principle to reason about these functions.

Nevertheless, MTF does not take into account the possibility of non well-founded objects, while we can see a revival of interest in these objects. This interest is essentially linked with some developments in Computer Science. Indeed, many objects met by computer scientists show non well-founded behaviors: looping processes, transition systems, paradox in natural languages and so on. Others are potentially infinite, only accessible to a partial and progressive knowledge, like strings, real numbers, formal series and so on. Semantics of such objects or phenomena are then given in a more natural and straightforward way inside universes including non well-founded sets.

Moreover, the traditional induction principles are not suited to define and reason about that type of objects. That led computer scientists like R. Milner, Bart Jacobs, Jan Rutten, Daniele Turi, Martina Lenisa (see for instance [44], [45], [37], [47], [48], [39], [40]) to develop an alternative approach, introducing dual principles said of definition and reasoning by *co-induction*.

Following that trend, I designed a non well-founded version of Map Theory named MTA which takes into account the existence of non well-founded objects. In the first part of the thesis, I showed MTA to be at least as powerful as $ZFC + AFA$, where AFA is the anti foundation axiom introduced by F. Honsell et M. Forti in [28], and popularized under a different formulation by P.Aczel in [1]. In the second part, I also showed the relative consistency of this new version in the framework of the κ-continuous semantics of λ-calculus, which is a generalization of the (omega-)continuous semantics of Scott to any regular cardinal κ. My system include a co-induction principle to reason about non well-founded maps and also a way to define those maps.

Two main questions concerning MTA are still open. The first one is linked to the research project I worked on at the Dept. of Informatics and Mathematics at the university of Udine (Italy). This project was part of a research program on the foundation of Informatics, Mathematics and Logic which was initiated by Ennio Di Giorgi at the "Scuola Normale Superiore" in Pisa. It is about the possibility to interpret in MTA, or a variant, a general foundational theory developed by M. Forti, F. Honsell, M. Lenisa et G. Lenzi ([30], [29]),and which includes a problematic axiom which consistency has still to be proved. The second question concerns the construction of a model for an alternative axiomatization of MTA. This version includes a scheme of definition by *co-induction* which is the dual in a strong sense of MTF definition by induction scheme. This scheme has a clear computational meaning contrary to the scheme present in the current axiomatization. Its inclusion would strengthen the interest of MTA for computer science by opening the way to computable implementations of co-inductive data type objects and of the functions dealing with these objects.

Notice that a good introduction to both MTF and MTA can be found in [53].

2.2 Postdoc, Dept. of Mathematics and Computer Science, University of Udine, Italy

After my PhD thesis I worked for 9 months as a part-time postdoc for the department of Mathematics and Computer Science of the University of Udine (Italy). I worked on the Non-Well-Founded Theory of Classes of

Ennio De Giorgi (who was professor of mathematics at the “Scuola Normale Superiore” of Pisa) and its embedding in MTA. After some generalizations of previous results from my thesis, I attempted to build a model of the theory plus a problematic axiom inside a model of MTA. The question of the existence of such a model is still open.

The report [52] which concerns that research in Udine can be obtained by request.

2.3 Postdoc, CEOL, Dept. of Computer Science, University College Cork, Ireland

The Centre for Efficiency Oriented Language (CEOL) is a laboratory funded by Science Foundation Ireland. It’s main goal is the development of a new programming language named MOQA which is especially designed to facilitate the average time analysis of it’s programs. In particular this language makes use of partial orders to control the multiplicities of the outputs on some type of sets of inputs called Random Structures. This control is a consequence of a property, called the Random Structure Preservation (RSP) property, of MOQA operations, and facilitate the determination of average time of programs. The development of the language involves order theory (and more generally graph theory) and average complexity. More informations about the laboratory can be find on its website:

http://www.ceol.ucc.ie

- My achievements in CEOL were:

    1. Improvements and comments on the seminal article introducing MOQA (see [49]).
    2. A technical and useful result about what we call the Reconstruction Problem.
    3. Generalizations of MOQA operations to every possible inputs. These generalizations were extracted from a continuous model I built for MOQA programs).
    4. Definition of a general criterion to characterize the RSP property.
    5. Average time of the basic operations of MOQA over some regular structures.

- Future possible research directions:

1. Generalization of the previous results for non-regular structures.
2. Generalization of the notion of Random Structure (to make it independent of partial orders).

Several of my results concerning MOQA can be found in the papers [54, 4, 43, 55] which are available on demand.

2.4 Present anf Future Research

During my postdoc at the university of Cork, I developed a cooperation with Dr. Alain Bretto from the University of Caen (France) in the area of graph theory. This cooperation leads to a journal publication [8] and several pre-publications [17, 18].

In the next years that collaboration in graph theory should be continued within three directions described in the subsections below where a graph is always supposed finite.

2.4.1 Hamiltonicity and Clique Coverings of Graphs

The first direction concerns the results of [17] and [18]. A well-known and fundamental property of graphs is *Hamiltonicity.* A connected graph is hamiltonian if it contains a spanning cycle. Determining if a graph is hamiltonian is known as NP-complete problem and no satisfactory characterization exists. Nevertheless, many sufficient conditions for hamiltonicity were found, usually expressed in terms of degree, connectivity, density, toughness, independent set, regularity and forbidden subgraphs.

In [31], Goodman and Hedetniemi gave two alternative sufficient conditions uniquely based on the existence of a *clique-covering* of the graph. This condition was recently generalized in [**?**] using the notion of *eulerian* clique-covering. It was also shown in [56], that there exists an eulerian clique-covering of a graph iff there exists a *normal* one, where a clique-covering is normal if it contains the closed neighborhood of every simplicial vertex of the graph. A polynomial algorithm to decide the existence of such a covering for every simplicial-connected graph (where a graph is simplicial-connected if every vertex is connected by a walk to a simplicial vertex) is also given in [**?**]. More general versions of the algorithm seem possible. It may also be possible to further generalize the new condition. Finally, a systematic comparison between this condition and the other existing conditions based on different principles would be interesting.

Another present research topic related to hamiltonicity concerns closure concepts. In [6], Bondy and Chvàtal introduced a way to get round the hamiltonicity problem complexity by using a closure of the graph. This closure is obtained in polynomial time by repeatedly adding edges between pairs of nonadjacent vertices which degree sum is greater or equal to the order of the graph, as long as such a pair exists. The closure is then proved to be hamiltonian iff the graph is. In particular, if the closure is a complete graph then the graph is hamiltonian.

Since this seminal article, several closure concepts preserving hamiltonicity were introduced (for a survey on the topic, see for instance [20]). In particular Z. Ryjàcek defined in [46] a closure concept for claw-free graphs based on local completion. The local completion is repeatedly performed on every *eligible* vertex, as long as such a vertex exists. Note that a strengthening of the closure concept of [46] was introduced in [19]. In the context of [31, **?**, **?**], closure concepts based on local completion are interesting since, then, the closure of a graph contains more simplicial vertices than the graph itself, making the search for a normal clique-covering easier. For instance, a closure in the sense of [46] has at most one *normal* eulerian clique-covering. Several new closure concepts based on local completion and based on *neighborhood-equivalence* are already developed and studied.

2.4.2 Cartesian Products of Hypergraphs

Hypergraphs are wellknown generalizations of graphs. Several properties of the cartesian product of hypergraphs were studied in [11] and additional ones are currently studied.

2.4.3 G-graph, a new way to associate group and graph

Algebraic Graph Theory is a vibrant field in Discrete Mathematics (see for instance [3, 5, 32, 34]), with numerous applications to Computer Science. Groups linked with graphs have arguably been the most famous and productive area of algebraic graph theory. A traditional way to associate a graph to a group is know as Cayley graph. For every group, there exists a corresponding *Cayley Graph*: for a group G and a subset S of generators of G, the Cayley Graph of G is the graph whose vertices are the elements of G, and where two vertices x and y are adjacent if and only if $y = s.x$ for some $s \in S$. Cayley Graphs have highly-regular properties, making them suitable for many applications in parallel computing, networks, cryptography and security (see for instance [24, 25, 26, 27] and the corresponding chapters in [3, 5, 32, 34]). However, Cayley graphs have also certain limitations:

- Many interesting graphs are not Cayley Graphs.

- Cayley Graphs are always regular and vertex-transitive, and so in particular they can never be semi-symmetric.
- Cayley Graphs do not provide much information about underlying groups.
- It is known that two isomorphic groups give rise to two isomorphic Cayley Graphs; yet the converse is not true, even for a subcategory of Abelian groups.

To overcome these limitations, the concept of a *G-Graph* was recently introduced and developed in [10, 13, 14, 12, 16], as a new way of associating a graph with a group G and a generator subset S of G. G-Graphs can be regular or non-regular; symmetric or semi-symmetric. For instance, both the Gray Graph and the Ljubljana Graph [23] are well-known semi-symmetric graphs which are also G-Graphs [14]. Moreover, in the Cayley case, taking $S = G$, where G is the group and S the generating set, leads to a complete graph. This is not the case for G-Graphs, which means that the group structure is now more adequately captured by the graph, and that the canonical association to the group of the G-Graph induced by setting $S = G$ is meaningful. In particular, it is proved in [13] that two Abelian groups are isomorphic iff their canonically-associated G-Graphs are.

Moreover, G-Graphs generalize Cayley Graphs in the sense that every Cayley Graph can be constructed from a G-Graph; more precisely, there exists a surjective functor from the category of G-Graphs into the category of Cayley Graphs. Several helpful properties are exhibited by every G-Graph: its automorphism group is non-trivial, it reveals key aspects of its underlying group, it can be constructed by a natural polynomial algorithm from its group [14], and it is connected. Note also that G-Graphs are k-partite, where k is the cardinality of the generator set, and often semi-regular (all vertices in the same part of the graph have the same degree), so they still retain some regularity properties.

Another interesting application of G-Graphs is the generation of symmetric and semi-symmetric graphs in a highly efficient way. In particular, it it possible to generate 95% of the Conder list of cubic symmetric and semi-symmetric graphs [21, 22] (which itself extends the Foster Census [7]) far more efficiently. The first algorithm for generating almost all quartic and quintic symmetric and semi-symmetric graphs (to a certain size) is based on G-graphs [13]. Finally, note that G-Graphs are quite general and include many famous graphs, including several generalized Petersen graphs, the Heawood, Pappus, Möbius-Kantor, Gray, and Ljubljana graphs, as well as the cube, hypercube, octahedral and cuboctahedral graphs.

G-graph theory is a new and promising area in of Algebraic Graph Theory which is already studied in several countries (University Jean Monnet, St-Etienne, France, University Komenského, Bratislava, Slovakia, University Delgi Studi di Messina, Italy, University of Belgrade, Serbia). Many properties and applications of these graphs have still to be developed. We enumerate now the questions we would like to address in the next few years in cooperation with Pr. Alain Bretto and the community working in the field:

- The importance in numerous applications of hamiltonicity, vertex and edge connectivity, diameter, girth and density as network parameters is well-known. So it seems fundamental for us to give some characterizations of these properties for G-Graphs.
- Another important goal is to make more precise the links between groups and graphs. In particular, it appears possible to generalize the result of [13] which concerns preserved isomorphisms to non-Abelian groups. Note that the answer to that question could be of major interest regarding the the graph isomorphism problem in complexity theory [38]. More generally, we would like to know what properties of graphs are readable from the group and conversely. A first application of that study will be the implementation of a more general group extraction algorithm than that given in [14], which should prove to be of considerable interest to the mathematical modeling community.
- The embedding of classical networks as G-graphs should be also very useful, as the extra generality over Cayley Graphs should greatly extend the network topologies to which these tools can be applied.
- We may investigate the links between G-Graphs and Extender Graphs.
- We may also apply G-Graphs to problems in cryptography and digital watermarking.

2.4.4 Wireless Sensor Networks

I recently developed a collaboration with Dr. Kalok Man in the domain of Wireless Sensor Networks (see [41, 42])

3 Teaching Experience

My professional experience in education is divided into three periods. During the first period, from 1985 to 1992, I worked as a monitor and teaching assistant in several state and private schools. In this framework of my job at the Professional High school of Ambérieux-en-Bugey (France), I taught Mathematics and French to an audience of teenagers with serious educational problems. My lectures were about basics of Mathematics and French grammar. The two last periods concern my academic experience and are now detailed below.

3.1 ATER, IUT of the University Clermont 1

During my PhD, I held a two years position as an ATER (a temporary lecturer position for PhD student) in Mathematics and Computer Science. My lectures took place in the GEA (management) department of the IUT (Institute of Technology) of the University Clermont1 (France). During this period, I was totally in charge of my students: conception of the courses, organization of the examination and grading:

- At the IUP (Professional University Institute), I taught mathematics to first year students in Management.
- At the IUT the audience was also students in Management. I was in charge of a first year course, where I taught Word, Excel, Access. I was also responsible for choosing course content, conception and teaching of a second year course, where I taught SQL (the universal request language for relational data bases) and Visual Basic (an object-oriented programming language).

3.2 Assistant Professor in Mathematics and Statistics

I taught for one year as an Assistant Professor in Mathematics and Statistics at the Mathematical Sciences Dept. of Georgia Southern University in Georgia (US). I taught College Algebra and Statistics to an audience of students who were not specialized in mathematics. The students were from different majors and were at different stages of their studies depending of the organization of their classes.

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