Scientific Report

First name / Family name	Erik Quaeghebeur
Nationality	Belgian
Name of the *Host Organisation*	CWI: Centrum Wiskunde & Informatica
First Name / family name of the *Scientific Coordinator*	Peter Grünwald
Period of the fellowship	01/12/2013 to 30/11/2014

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

- **CWI World Cup Experiment**
  Team members: Erik Quaeghebeur (lead), Chris Wesseling (website, backend, advisory), Emmanuelle Beauxis-Aussalet (interface expertise), Tom Sterkenburg (advisory), Teresa Piovesan (advisory)

  We wished to test the elicitation of sets of desirable gambles in practice. A special betting pool for 2014 World Cup was devised and set up. For this, a gamble selection interface was designed and an algorithm for fair gamble assignment was developed. The experiment was run during the World Cup, with increasing number of participants (up to about a hundred) and data was collected. The analysis of this data will soon begin.

  (In support of this project, Cython bindings for the GNU Linear Programming Toolkit were created. This side project is ongoing.)
- **A propositional CONEstrip algorithm** (see II)
- **Connecting choice functions with sets of desirable gambles** (see III & IV.2)
- **Sleeping Beauty**
  Supported by discussions with Peter Grünwald and Tom Sterkenburg

  The *Sleeping Beauty* problem is a probabilistic puzzle, i.e., a seemingly simple problem about which discussion rages in the literature. I have been working on an imprecise-probabilistic analysis that should make explicit some of the problem's aspects that have caused confusion.
- **Workshop on the occasion of Teddy Seidenfeld's CWI visit**
  CWI, Amsterdam, Netherlands; 3-4 July 2014
  Co-organized by Peter Grünwald and Erik Quaeghebeur
- **9th International Symposium on Imprecise Probability: Theories and Applications (ISIPTA '15)**
  Member of the Steering Committee and Program Committee Board
- **Conference Program Committee membership and Journal reviewing**
  UAI 2014, IPMU 2014, IPSP 2014, ECSQARU 2015
  International Journal of Approximate reasoning

II – PUBLICATIONS DURING YOUR FELLOWSHIP

- **Desirability** Erik Quaeghebeur
  Chapter 1 of *Introduction to Imprecise Probabilities* (edited by Th. Augustin, F. Coolen, G. de Cooman, and M. Troffaes), 1–27, Wiley
- **A propositional CONEstrip algorithm** Erik Quaeghebeur
  Information Processing and Management of Uncertainty in Knowledge-Based Systems; Communications in Computer and Information Science 444, 2014, 466-475, Springer; doi:10.1007/978-3-319-08852-5_48

We present a variant of the CONEstrip algorithm for checking whether the origin lies in a finitely generated convex cone that can be open, closed, or neither. This variant is designed to deal efficiently with problems where the rays defining the cone are specified as linear combinations of propositional sentences. The variant differs from the original algorithm in that we apply row generation techniques. The generator problem is WPMaxSAT, an optimization variant of SAT; both can be solved with specialized solvers or integer linear programming techniques. We additionally show how optimization problems over the cone can be solved by using our propositional CONEstrip algorithm as a preprocessor. The algorithm is designed to support consistency and inference computations within the theory of sets of desirable gambles. We also make a link to similar computations in probabilistic logic, conditional probability assessments, and imprecise probability theory.

- **Characterizing coherence, correcting incoherence** Erik Quaeghebeur *International Journal of Approximate Reasoning*, Elsevier; in press; doi:10.1016/j.ijar.2014.03.005

  Lower previsions defined on a finite set of gambles can be looked at as points in a finite-dimensional real vector space. Within that vector space, the sets of sure loss avoiding and coherent lower previsions form convex polyhedra. We present procedures for obtaining characterizations of these polyhedra in terms of a minimal, finite number of linear constraints. As compared to the previously known procedure, these procedures are more efficient and much more straightforward. Next, we take a look at a procedure for correcting incoherent lower previsions based on pointwise dominance. This procedure can be formulated as a multi-objective linear program, and the availability of the finite characterizations provide an avenue for making these programs computationally feasible.

- **Accept & Reject Statement-Based Uncertainty Models**
  Erik Quaeghebeur, Gert de Cooman, Filip Hermans
  Int. J. of Approximate Reasoning, Elsevier; under minor revision; arxiv:1208.4462

  We develop a framework for modelling and reasoning with uncertainty based on accept and reject statements about gambles. It generalises the frameworks found in the literature based on statements of acceptability, desirability, or favourability and clarifies their relative position. Next to the statement-based formulation, we also provide a translation in terms of preference relations, discuss—as a bridge to existing frameworks—a number of simplified variants, and show the relationship with prevision-based uncertainty models. We furthermore provide an application to modelling symmetry judgements.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

- **Information-Theoretic Learning course** Leiden University, 2014 Spring term
  Lecturer: Peter Grünwald

- **Annual Meeting of the VvS+OR 2014** Utrecht, Netherlands; 20 March 2014

- **Workshop on Imprecise Probabilities in Statistics and Philosophy (IPSP 2014)** München, Germany; 27-28 June 2014
  Collaborator on presented research (on *Connecting choice functions and sets of desirable gambles*, with A. Van Camp, speaker, and G. de Cooman, 27 June 2014)

- **16th Conference on the Foundations of Utility and Risk (FUR 2014)**
  Rotterdam, Netherlands; 29 June – 1 July 2014
  Session Speaker (on *Modelling risk & uncertainty using accept & reject statement, 30 June 2014)*

- **15th International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems (IPMU 2014)**
  Montpellier, France; 15-19 July 2014
  Session speaker (on *A propositional CONEstrip algorithm*, 18 July 2014)

- **6th SIPTA Summer School** Montpellier, France; 21-25 July 2014
  Co-organizer and lecturer (on *Inference*, 24 July 2014)

- **7th Workshop on Principles and Methods of Statistical Inference with Interval (and more generally imprecise) Probability (WPMSIIP 2014)**
  Ghent, Belgium; 7-12 September 2014
  Session chair, session Speaker (on *Sleeping beauty*), ad-hoc speaker (on *Imprecise probabilistic non-parametric predictive inference*)

- **ABCDE Seminar IV** Pisa, Italy; 23-24 October 2014

IV – RESEARCH EXCHANGE PROGRAMME (REP)

1. **Imprecise Probabilities Group at IDSIA (Istituto Dalle Molle di Studi sull'Intelligenza Artificiale)** Lugano, Switzerland; 15-21 June 2014
   Host: Marco Zaffalon; collaborators: Cassio de Campos, Alessandro Antonucci

   We extensively discussed *qualitative influences in credal networks.* Credal networks are imprecise-probabilistic generalizations of Bayesian networks; qualitative influences are (here for us) inequality constraints on dependencies in the network. We worked out a research program for a paper on (deductive) inference in credal networks including such qualitative influences and studied the existing literature (mostly on QPNs, Qualitative Probabilistic Networks).

2. **SYSTeMS Research Group, Ghent University**
   Ghent, Belgium; 7-12 September 2014
   Host: Gert de Cooman; other collaborators: Arthur Van Camp, Vladimir Vovk

   With Arthur Van Camp and Gert de Cooman, I worked on the topic of Arthur's PhD research: connecting the theory of sets of desirable gambles with the theory of choice functions. We discussed the possibility of changing the current approach, i.e., starting from choice functions and working towards sets of desirable gambles. The change would be to start by defining an appropriate generalization of sets of desirable gambles and then derive a choice function theory from that.

   Because he was present for the workshop held in Ghent concurrently with my REP, I had the opportunity to discuss with Vladimir Vovk (Royal Holloway, University of London) about predictive inference methods. We focused on deriving game-theoretic quality measures for non-parametric predictive inference models.