

CURRICULUM VITAE

HANNA USCKA-WEHLOU, PH.D.

I. PERSONAL DATA:

- Born in Wąbrzeźno (Poland), February 10, 1973.
- Citizenships: Polish and Swedish.
- Civic Registration Number: 730210-9207.
- Married, 2 children (a daughter born 2002 and a son born 2005).
- Lives in Uppsala (Flintstensvägen 10, SE-752 67 Uppsala).
- Countries of residence:
 - (1) Poland (February 1973 – December 1995)
 - (2) Belgium (January 1996 – October 2001)
 - (3) Sweden (October 2001 – onwards).
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II. EDUCATION:

- September 2009 – Ph.D. in mathematics from Uppsala University (Ph.D. student 2003–2009, of which almost 19 months on maternity leave). Thesis: *Digital Lines, Sturmian Words, and Continued Fractions*. Advisor: Professor Christer Kiselman.
- September 1997 – M.Sc. in theoretical mathematics (with pedagogical qualifications) from Copernicus University in Toruń (Poland). Graduated with top honors. Thesis: *Continuation method for contractions and applications in differential calculus*. Advisor: Professor Andrzej Granas.
- June 1992 – graduated from Liceum IV in Toruń, Poland. I was educated in a class with a strong mathematical program, with math teachers from the Department of Mathematics at the Copernicus University. I participated four times in the Mathematical Olympiad and twice reached the national final in Warsaw. I also won a stipendium of the National Foundation for Exceptionally Gifted Children during this period.

III. LANGUAGES:

- Polish (native speaker).
- Swedish, English, Dutch (fluent).
- Russian (reading, understanding, some speaking).

IV. RELEVANT PROFESSIONAL EXPERIENCE:

- 2009-11-01 – 2010-07-31: working on the project *Mathematical methods in modeling and analysis of concurrent systems* in cooperation with the Group of Formal Languages and Concurrency from the Faculty of Mathematics and Computer Science of the Copernicus University in Toruń. During the period 2010-02-01 – 2010-07-31 this project has been officially run by the Department of Computer Science at Uppsala University. My scientific advisor is Professor Parosh Aziz Abdulla. I got two scholarships for this project: one of them (the Lennander Scholarship) from Uppsala University, the second one (Magnuson scholarship) from The Royal Swedish Academy of Sciences.
- 2003-07-01 – 2009-09-30 (maternity leave 2005-06-07 – 2007-01-01): Uppsala University. Ph.D. position in The Graduate School in Mathematics and Computing (Forskarskolan i Matematik och Beräkningsvetenskap, FMB), teaching (one-dimensional calculus).
- 2000-10-15 – 2001-03-31: VUB (Flemish University of Brussels, Belgium). I worked in the project EXPLOOT led by Professor Ivan Cnop (planning, designing, and writing lesson packages in *Mathematica* for students); some teaching. I was proposed to prolong the contract with VUB but I did not accept it because I knew I would move to Sweden.

V. SCHOLARSHIPS AND AWARDS:

- The Lennander Scholarship, Uppsala University (2010).
- Magnuson Scholarship, The Royal Swedish Academy of Sciences (Kungliga Vetenskapsakademien) (2010).

VI. RESEARCH INTERESTS:

- Combinatorics on words.
- Combinatorial aspects of theoretical computer science (Petri nets, theory of traces).

A more detailed description of my research interests is to be found in a separate document (*Description of research*).

VII. MY RESEARCH UNTIL NOW:

My research until now has been focused on arithmetical properties of digital straight lines with irrational slopes, and, consequently, on Sturmian words. I defended my Ph.D. Thesis *Digital Lines, Sturmian Words, and Continued Fractions* on September 25 (2009). In this thesis I presented a continued-fraction based description of digital lines with irrational slopes and of Sturmian words. This description reflects the run-hierarchical structure of such lines (and words) as defined by Azriel Rosenfeld in 1974. There exist other continued-fraction based descriptions, like for example the method by standard sequences, but mine is the first one which shows the hierarchy of runs. The main reason for this is a special role which some continued-fraction elements equal to 1 (called *essential ones*) got in the description. Because of this property of reflecting the run-hierarchical structure of Sturmian words, my method opened a number of new geometrically motivated combinatorial problems in the combinatorics on words.

I defined two equivalence relations on the set of slopes $]0, 1[\setminus \mathbf{Q}$. Both relations are defined on continued-fraction elements in the expansion of slopes. One of them groups together all the slopes generating straight lines with the same run length on each level in the hierarchy, the second one groups together those which lead to lines with the same construction in terms of short and long runs on all digitization levels. I examined the equivalence classes under both relations and got a Fibonacci-related result for the suprema of classes under the second equivalence relation. I showed how each digital line (or Sturmian word) is defined by two sequences of positive integers. One of them, the *sequence of length specification*, is infinite and has all the elements indexed by $n \geq 2$ greater than 1. The second one must be *essential*, i.e., its first element must be greater than 1, the sequence must be increasing, and the difference between each two consecutive elements must be greater than 1. Essential sequences can be indexed by \mathbf{N}^+ , by integer intervals $[1, M]$ (for any $M \in \mathbf{N}^+$), or can be empty.

I formulated and proved a new fixed-point theorem for Sturmian words, by analogy with the famous idea of Kolakoski formalized in a form of the fixed-point theorem for the run-length encoding operator. My fixed-point theorem concerns the run-construction encoding operator (defined by me), which maps all the upper mechanical words with slopes from $]0, 1[\setminus \mathbf{Q}$ (which are Sturmian) on the corresponding constructional words, defined by means of the essential sequences for these words. Fixed points of the run-construction encoding operator are special among all Sturmian words. Generally, for the run-hierarchical description of Sturmian words we need two sequences of positive integers, while in the case of the fixed points one of them (the sequence of length specification) suffices.

VIII. MY MOST IMPORTANT PUBLICATIONS:

- 07-1 Uscka-Wehlou, Hanna, 2007. Digital lines with irrational slopes. *Theoretical Computer Science* **377**, 157–169.
- 08-1 Uscka-Wehlou, Hanna, 2008. Continued Fractions and Digital Lines with Irrational Slopes. In D. Coeurjolly et al. (Eds.): DGCI 2008, LNCS **4992**, pp. 93–104.
- 08-2 Uscka-Wehlou, Hanna, 2008. A run-hierarchical description of upper mechanical words with irrational slopes using continued fractions; 15 pp. In *Proceedings of 12th Mons Theoretical Computer Science Days (Mons, Belgium), 27–30 August 2008*. <http://www.jmit.ulg.ac.be/jm2008/index-en.html>.
Preprint: <http://wehlou.com/hania/files/uu/mons08rev.pdf>.
- 09-1 Uscka-Wehlou, Hanna, 2009. Run-hierarchical structure of digital lines with irrational slopes in terms of continued fractions and the Gauss map. *Pattern Recognition* **42**, 2247–2254.
- 09-2 Uscka-Wehlou, Hanna, 2009. Two equivalence relations on digital lines with irrational slopes. A continued fraction approach to upper mechanical words. *Theoretical Computer Science* **410** (38–40), 3655–3669.
- 09-3 Uscka-Wehlou, Hanna, 2009. Sturmian words with balanced construction; 12 pp. In *Proceedings of Words 2009, the 7th International Conference on Words (Salerno, Italy), 14–18 Sept. 2009*. <http://words2009.dia.unisa.it/accepted.html>.
Preprint: <http://wehlou.com/hania/files/uu/words2009.pdf>.

- 09-4 Uscka-Wehlou, Hanna, 2009. *Digital Lines, Sturmian Words, and Continued Fractions*. Ph.D. Thesis, 152 pp. In *Uppsala Dissertations in Mathematics* **65**. ISBN: 978-91-506-2090-0.
- 10-1 Uscka-Wehlou, Hanna, 2010. Continued fractions, Fibonacci numbers, and some classes of irrational numbers. Published in *Acta Mathematica Academiae Paedagogicae Nyíregyháziensis* **26(1)**.

All my publications and scientific presentations (with abstracts) are listed in a separate document (*Publications and scientific presentations*).

IX. CONFERENCE TALKS AND OTHER SCIENTIFIC PRESENTATIONS:

- 2003-12-15: Presentation *Digital lines* at the Seminar of the Centre for Image Analysis, Uppsala.
- 2004-11-15–16: Presentation *Digital lines* during the FMB-FMD Open House Conference, Uppsala University.
- 2005-01-24: Presentation *Theory of digital lines* at the Seminar of the Centre for Image Analysis, Uppsala.
- 2008-04-16–18: The 14th International Conference on Discrete Geometry for Computer Imagery, DGCI 2008 (Lyon, France). Poster and a short oral presentation *Continued Fractions and Digital Lines with Irrational Slopes*.
- 2008-08-27–30: The 12th Mons Theoretical Computer Science Days, JM 2008 (Mons, Belgium). Conference talk *A run-hierarchical description of upper mechanical words with irrational slopes using continued fractions*.
- 2008-11-07–08: Sonja Kovalevskydagarna at Uppsala University: I was a workshop leader for the workshop called *Groups* and I was a member of the problem-solving group.
- 2009-09-14–18: The 7th International Conference on Words, Words 2009 (Salerno, Italy). Conference talk *Sturmian words with balanced construction*.
- 2009-09-25: Presentation of my Ph.D. thesis *Digital Lines, Sturmian Words, and Continued Fractions* at Uppsala University. The faculty Opponent: Dr. Damien Jamet (Nancy); the members of the Grading Committee: Dr. Petter Brändén (Stockholm University and the Royal Institute of Technology), Docent Rikard Bögvald (Stockholm University), Professor Isabelle Debled-Rennesson (Laboratoire Lorrain de Recherche en Informatique et ses Applications, Nancy), Professor Anders Heyden (Lund University), and Docent Warwick Tucker (Uppsala University).
- 2009-10-27: Presentation *Classes of irrational numbers defined by their continued fraction expansions* at the Seminar *Automorfizmy i derywacje* in the Faculty of Mathematics and Computer Science of the Copernicus University in Toruń, Poland.
- 2009-12-02: Presentation *Some combinatorial problems related to digital straight lines with irrational slopes and to balanced aperiodic words* at the Combinatorics Seminar at KTH, the Royal Institute of Technology, Stockholm, Sweden.
- 2010-02-22–25: Scientific visit at the Faculty of Mathematics and Computer Science of the Copernicus University in Toruń, Poland. Discussions about the project *Mathematical methods in modeling and analysis of concurrent systems* during a

workshop on Petri nets and traces, organized by the group *Formal Languages and Concurrency*.

- 2010-07-19–23: Participation in the Workshop MASYW 2010 (Mathematical methods in modeling and analysis of concurrent systems) in Tleń (Poland) organized by the research group *Formal Languages and Concurrency* from the Faculty of Mathematics and Computer Science of the Copernicus University in Toruń, Poland.

X. REFERENCES:

- Professor Christer Kiselman
Uppsala, Sweden; kiselman@math.uu.se, 0708-870708.
- Dr hab. Edward Ochmański
Toruń, Poland; edoch@mat.uni.torun.pl.
- Dr Damien Jamet
Nancy, France; Damien.jamet@loria.