Language Processing Systems Laboratory

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The research and education activities in this laboratory focus on the theoretical and practical aspects related to formal languages, language processing, and language processing systems. In paticular, the work covered by this laboratory includes the following areas.

- Formal languages and automata;
- Term rewrite systems;
- Declarative languages;
- Formal semantics of languages;
- Computation mechanisms and modelling; and
- Discrete mathematics.

The research in this laboratory is devided into two parts:

The first part consists of the work that follows the research in the above areas. One of the most important purposes of it is to provide the foundations for the education of language processing systems, programing languages, and formal language theory.

The second part is the creative study in some specific areas ralated to language processing systems. The research activities of this part are based on the voluntary work of each faculty member. Currently, we are working on

- Characterizations of language classes;

- Foundation and implementation of declarative programming languages, such as functional, logic and functional-logic programming;
- Operational semantics of declarative languages;
- Theory and implementation of XML processing languages;
- Parallel/Distributed computation systems, such as compiler design for vector/matrix parallel computer architecture;
- Pattern Generation on Two Dimensional Cellular Space; and
- Others related to language processing systems;

Functional languages based on reduction have several properties such as deterministic and lazy evaluation and higher order definitions, but they lack other useful properties such as partial data structure and logical variables. On contrary logic languages based on unification allow partial data structure and logical variables but lack deterministic and lazy evaluation as well as higher order definitions. From this point of view it seems natural to unify both languages into one paradigm in order to obtain a language, called a functional logic language, with more expressive power than both functional and logic languages. To develop an efficient operational semantics for such unified model is studied in this laboratory.

Theoretical aspects of narrowing, extension of the notion of narrowing to higher-order narrowing, and others are studied in this laboratory, since they are recognized as the most important mechanisms of computation, especially in functional-logic programming languages.

ML is widely used in real world nowadays, especially for data exchange via the Internet and for data store within Web services. Thus XML processing gains importance and then research to ensure its safety and robustness mathematically should be urged. For this purpose, a study of a declarative XML processing language from theoretical and practical aspects is undertaken in this laboratory. Its computational model is hedge rewriting, an extension of term rewriting. The current study is focused on pattern matching of regular hedge patterns against hedges because it is a key mechanism of declarative XML processing. Algorithms for efficient pattern matching and its implementation are studied in this laboratory.

The recent parallel/distributed computation environment requires the development of a new language model and its processing model/system for such an environment. To design new languages and language processing systems is the key work for the next development of the computer society, and to study for establishing such models and implementing as real systems for evaluation is considered

one of the most important subjects for this laboratory. Hence the members of this laboratory study on the topics in this field.

The education on the subjects related to languages and language processing systems is also the important mission of this laboratory. The courses for undergraduate students given by the members of this laboratory include Computer Literacy II, Advanced Algorithm, Automata and Languages, Language Processing Systems, and Operating Systems. Those for graduate program include Advanced Automata and Languages, Complexity Theory, Declarative Processing, Computation Theory, and Advanced Graph theory. The latter two courses started newly in this year according to the revision of the graduate program.

One of the member of this laboratory with some professors in other universities translated the book, "THE ANNOTATED TURING:A Guided Tour through Alan Turing Historic paper on Computability and the Turing Machine" by C. Petzold into Japanese and published it.

Summary of Achievement

Refereed Journal Papers

Unrefereed Papers

[okawa-01:2012] Satoru Watanabe and Satoshi Okawa. Circle Generation on Two-Dimensional Cellular Automata. *RIMS Kokyuuroku*, (1809):161 – 168, 2012.

In this paper, we define a pattern and generation of a figure, similar to the pattern, on a two dimensional cellular automaton. For any positive integers m and n, we construct an $m \times n$ cellular automaton which generates a circle with the appropriate size and at the appropriate position. It takes $O(d^3)$ steps, where $d = \min\{m, n\}$.

Refereed Proceeding Papers

[okawa-02:2012] Zoltan Esik and Satoshi Okawa. On context-free languages of scattered words. In Hsu-Chun Yen and Oscar H. Ibarra, editors, *Developments of Language Theory*, volume 7410, pages 142 – 153. Springer, 2012.

In this paper, we show that a Muller context-free language (MCFL) of scattered words is a Buchi context-free language(BCFL) iff the rank of every word in the language is bounded by an integer depending only on the language. We also establishe operational characterizations of BCFL's of well-ordered words.

Unrefereed Papers

[okawa-03:2012] Satoru Watanabe and Satoshi Okawa. Circle Generation on Two-Dimensional Cellular Automata. In *RIMS2013*, 2013.

In this paper, we define a pattern and generation of a figure, similar to the pattern, on a two dimensional cellular automaton. For any positive integers m and n, we construct an $O(d^2)$ algorithm for an $m \times n$ cellular automaton to generate a circle with the appropriate size and at the appropriate position, where $d = \min\{m, n\}$.

[okawa-04:2012] Shohei Watanabe and Satoshi Okawa. A Simple Extended Star Graph: A Proposal of New Network Topology and Its Fundamental Properties. In *IPSJ Tokoku Branch meeting at University of Aizu*, 2013.

In this paper, we propose a new network topology defined as the Star graph with adding edges of the form (u, v) where $u = (u_1 u_2 \cdots u_n)$ and $v = (u_2 \cdots u_n \overline{u}_1)$. And we investigate it fundamental properties and prove the hamiltonicity of it.

[taro-02:2012] Y. Takano and T. Suzuki. The Implementation of a Visual Programming Environment for Haskell Programs with Arrows (in Japanese). In *the 6th IPSJ tohoku workshop, 2012*, pages 1–8, March 2013.

It is difficult to learn arrows in the functional programming language Haskell because programming with them is often very complicated. Last year we proposed a design of visual programming environment for Haskell programs with arrows and an algorithm for the generation of Haskell programs in textual form from a diagram written with the visual programming environment. We implement the visual programming environment as a plugin of Eclipse, one of most popular integrated programming environment, and evaluated it. In this paper, we describe the details of implementation and the result of evaluation. We also discuss the difficulty of our programming environment found by the evaluation and how to overcome it.

Chapters in Book

[taro-03:2012] S. Okui M. Hamana T. Ida, T. Suzuki and T. Yamada. *The Annotated Turing (in Japanese)*, chapter 12-14. Nikkei BP, 2012.

Grants

[taro-04:2012] T. Suzuki. Grant-in-Aid for Scientific Research (C), 2011-2013.

Academic Activities

[okawa-05:2012] S. Okawa, 2012.

serve as a reviewer of IEICE Transactions

[okawa-06:2012] S. Okawa, 2012.

serve as a reviewer of the Proceedings of Theoretical computer Science

[taro-05:2012] Taro Suzuki, 2011.

member

[taro-06:2012] Taro Suzuki, 2011.

member

[taro-07:2012] Taro Suzuki, 2011.

member

Ph.D and Others Theses

[okawa-07:2012] Daich Nihei. Graduation Thesis: Regular Triangle Generation on Two-Dimensional Cellular Automata, University of Aizu, 2013.

Thesis Advisor: S. Okawa

[okawa-08:2012] Yuji Mizuno. Graduation Thesis: A Simple Extended Star Graph: A Proposal of New Network Topology and Its Fundamental Properties, University of Aizu, 2013.

Thesis Advisor: S. Okawa

[taro-08:2012] Yudai Takano. Graduation Thesis: Implementation of a visual programming environment for Haskell programs with arrows, University of Aizu, 2012.

Thesis Advisor: T. Suzuki