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Genetic Programming and Evolvable Machines: Books and other Resources

In this column I will present summaries of published GP/EM literature, Internet based sources of GP/EM information and our plans for future reviews of GP/EM resources (books, world wide web (www) sites, products and programs).

1. Introduction

Both areas, genetic programming and evolvable machines, are still principally scientific in character with most visible work being carried out by scientists who publish their results. Thus we can get a picture of the field from its scientific output. Any picture is bound to be incomplete, in particular our approach will unfortunately miss applications of GP or EM that have not been published, e.g. because they are too sensitive to release.

2. Books

There are already at least 10 books directly relating to GP published in English with more to come. In the forthcoming issues of *Genetic Programming and Evolvable Machines* we will review many of them (shown with ⋆).

- John Koza's 3 seminal tomes each of which is accompanied by a videotape *Genetic Programming*, *II* and *III* ⋆.
- Three edited collections in MIT press' *Advances in Genetic Programming* ⋆ series.
- *Genetic Programming – An Introduction* ⋆. A comprehensive summary and GP's first text book.
- A number of books on advanced technical material and derived mostly from PhD. thesis projects, among them Nordin's *Evolutionary Program Induction of Binary Machine Code and its Applications*, Langdon's *Data Structures and Genetic Programming* ⋆, Dracopoulos' *Evolutionary Learning Algorithms for Neural Adaptive Control* and Ryan's *Genetic Programming and Software Re-Engineering: The Scare Project* ⋆.
- There are some foreign language GP books. As soon as translations into English are being done, we shall review them as well. Jacob's *Principia Evolvica – Simulierte Evolution mit Mathematica* ⋆ is among them.

The situation in the field of evolvable machines is not as bright yet. However there are already a number of books:

- Tomassini and Sanchez's *Towards Evolvable Hardware: The evolutionary engineering approach.* Based on the 1995 Lausanne workshop on evolvable hardware but also includes introductory material.

- Sipper's *Evolution of Parallel Cellular Machines: The Cellular Programming Approach.*

- Thompson's prize winning *Hardware Evolution. Automatic Design of Electronic Circuits in Reconfigurable Hardware by Artificial Evolution.*

- Mange and Tomassini's *Bio-Inspired Computing Machines: Towards Novel Computational Architectures.*

3. Proceedings

Many evolutionary computation conferences have accepted GP/EM papers or even had GP/EM tracks. For example the ICGA, PPSN, EP and CEC series of conferences. However since 1996 there has been an annual conference on GP in the USA and since 1998 this has been augmented by a European GP conference. Both have been accompanied by informal late breaking papers. Additionally there have been a number of GP workshops which were not formally published.

In a similar development, a bi-annual international conference on evolvable systems (ICES) has been organized every two years since 1996. Last year this was augmented by a workshop on evolvable hardware held for the first time in the USA.

This year GECCO (a joint conference between GP and ICGA), PPSN, CEC, EuroGP and ICES will again hold conferences.

4. Publication Summary

Regarding GP, many of the statistics presented here are derived from the GP-bibliography[1]. The bibliography is available from the Internet in a variety of formats and locations. For example `ftp://ftp.cs.bham.ac.uk/pub/authors/W.B.Langdon/biblio/gp-bibliography.bib`. Unfortunately, no similar effort has been undertaken for the literature on evolvable hardware. As a result statistics can only be presented for GP.

As of September 1999 there were 1369 GP entries in the GP bibliography (excluding unpublished, miscellaneous, master thesis and undergraduate students). Figure 1 shows the number of each entry according to when they where published and by type. Naturally most papers were published in conference proceedings. Figure 1 shows an initially exponential rise followed by a rapid linear increase since 1997. To some extent the apparent reduction in growth may be an artifact of the data collection process. A lot of effort was devoted to ensuring the GP bibliography was as complete as possible up to 1996 (corresponding to the publication of

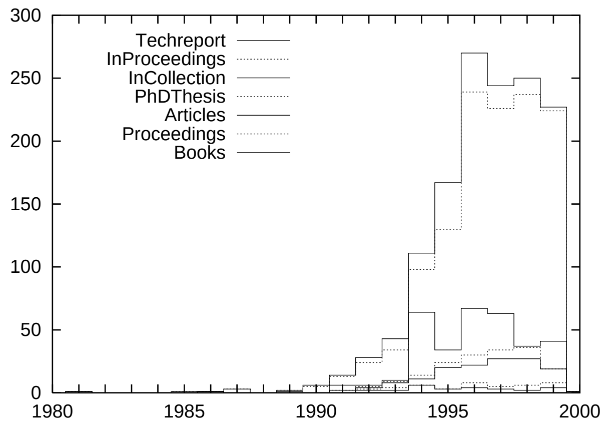

Figure 1. Number of genetic programming entries in the gp-bibliography, excluding unpublished, misc, masters thesis and undergraduate students. (Data after 1998 are less complete)

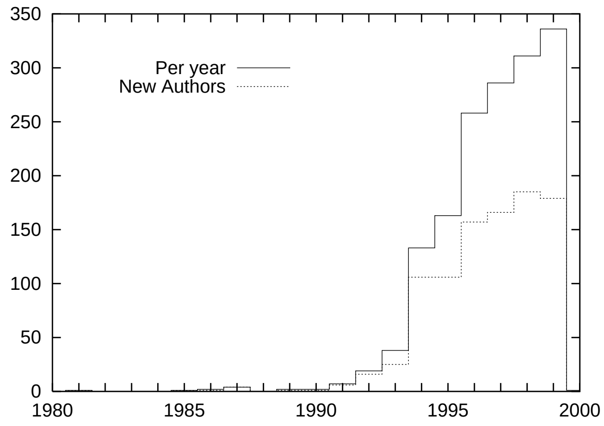

Figure 2. Approximate number of authors and co-authors of genetic programming entries in the gp-bibliography, excluding unpublished, misc and masters thesis. The lower curves plots the number of authors who had not previously published in GP.

Advances in Genetic Programming volume 2 which contains an annotated bibliography of GP). Since then there have been GP publications which have escaped recording in the bibliography.

Figure 2 plots the number of people active in GP (i.e. according to the GP bibliography they published in a given year). The total number of people who have published GP related papers is about 955.

5. Internet

The GP community has always made extensive use of the Internet. For example with the early establishment (1992) of the GP mailing list `genetic-programming@cs.stanford.edu` and ftp archive (now moved to `ftp://ftp.mad-scientist.com/pub/genetic-programming`). While the GP mailing list continue to be very active to some extent the ftp archive has been supplanted by the use of individual home pages. While it remains a useful resource, newer material is often scattered across the world wide web. The evolvable machines community is perhaps more tightly knit and has not, as yet, made such extensive use of the Internet via ftp, world wide web pages or mailing lists. However a summary www page can be found at `http://www.cogs.susx.ac.uk/users/adrianth/EHW_groups.html`.

Back in November 1997 Altavista listed more than 76 different sites directly related to GP (excluding personal home pages). Now (September 1999) there are approximately 310 personal home pages written by people interested in GP or evolvable machines (see `http://www.cwi.nl/~bill/homepages.html` for GP pages).

6. Products

The number of products making GP available to ordinary users or incorporating GP is still small. A handful are known. (For example AIM Learning Systems' Discipulus ⋆, Cap Gemini's OMEGA, Hanke and Hörner's Genetic Programming Control and New Light Industries' Generator and Chemsolver).

In the long run, this list will surely grow and we want to make sure that products based on GP are reviewed here for the practitioner.

7. Freeware

On the other hand there is a wealth of freely available software of increasing sophistication. Most researchers continue to use either home grown software or public domain software provided by other researchers. Here we briefly list by a few of them:

C and *C++* GP implementations include Zongker's *lilgp* `http://garage.cse.msu.edu/software/software-index.html` and Andre's *DGPC* `http://http.cs.berkeley.edu/~dandre/gp.tar.gz`. Lilgp has proved popular with updated versions available both from Michigan State University and Sean Luke. Singleton's *GPQuick*, Tackett's *SGPC* Simple GP in C and Fraser's *gpc++* can all be found in the GP ftp archive at `ftp://ftp.mad-scientist.com/pub/genetic-programming/code`. The archive also contains lisp code for Koza's first two books, and GP implementations in *SmallTalk, Mathematica* and *Prolog*. Java implementations include Qureshi's *GPsys* `http://www.cs.ucl.ac.uk/staff/A.Qureshi` and Chong's GP across the Internet `http://studentweb.cs.bham.ac.uk/~fsc/`.

8. Conclusions

In these pages I have summarised the existing GP/EM literature and indicated the books and products we shall review in future issues. In addition to the resources I mentioned above, we expect to review other recent books in the area, e.g. Bentley's *Evolutionary Design*.

I have indicated our communities' heavy use of the Internet and we also plan to publish reviews of important world wide web pages, as well as other products and even the more important freeware packages.

W. B. Langdon

Notes

1. The GP bibliography was started from John Koza's bibliography (published in Genetic Programming II). Over the years I have been greatly assisted in the maintenance and expansion of the GP bibliography by the subscribers to the genetic-programming electronic mailing list. I would also like to thank Dave Goldberg, Bill Porto and Annie S. Wu for timely information on the GECCO'99 and CEC'99 conferences.