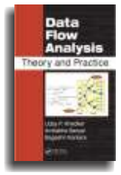
Data Flow Analysis: Theory and Practice



Uday Khedkar, Amitabh Sanyal & Bageshri Karkare
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395 Pages
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Data flow analysis emerged as a research area in the days of FORTRAN. Solutions to data flow problems are used by optimizing compilers of procedural languages like C++, Java, and C#. Beyond optimization, program flow analysis is also used for verifying properties of programs, such as, whether a program has a buffer overflow. Data Flow Analysis:Theory and Practice covers the whole gamut of algorithms that are at the heart of advanced compilers.

In spite of the significance and long history of data flow analysis, Khedkar et al.'s. book is the first to make the material easily accessible to novices and practitioners, while also being comprehensive. Aho et al.'s classic Compiler Construction, introduces the subject, but does not treat it in depth. Muchnick's Advanced Compiler Design is overwhelming with detail. Nielsen et al.'s Principles of Program Analysis provides a detailed theoretical treatment of the topic, but at a level not easily accessible to a practitioner or a student.

Khedkar et al. provides an easy introduction to the problem of data flow analysis, and its significance in the context of compiler optimization and program verification. The book brings the problem space alive by using well-crafted examples to illustrate classical problems such as live variable analysis, dead variable analysis, available expression analysis, and others. After introducing individual problems and their solutions, it generalizes from them and develops the theoretical framework for data flow analysis. Since the theory naturally flows from the examples, theoretical constructs that can otherwise be quite intimidating become accessible to novices and practitioners. These theoretical abstractions grounded with suitable examples are then used to present more difficult problems, such as pointer analyses and interprocedural analyses. The subject is brought to a close with a discussion on how to implement the concepts in GCC, the GNU C Compiler.

Khedkar et al.'s book fills a void long felt by teachers and researchers such as myself. It presents in less than 400 pages, a theoretically precise, accurate, and complete map of over forty years of research in the subject. This book is necessary reading for a graduate student pursuing research in program analysis. It may be used as a textbook for a graduate course in advanced compiler optimization, or as an additional resource in a course in compiler construction.

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Q & A

1. How can I find out more about CDEEP's activities?
Visit http://www.cdeep.iitb.ac.in.

2. Are the same courses available every semester?
No, a course is usually offered every alternate semester (July-Nov. or Jan.-April). However, there is no guarantee that a course once transmitted through CDEEP will be repeated.

Prof. D. V. Pai

Prof. Devidas Vyankatesh Pai has been a faculty member of the Department of Mathematics, IIT Bombay, since 1967. He received his Ph.D. degree from IIT Bombay in 1972 while continuing to work as a faculty member. During his tenure as Head of the Department from 1984-87, considerable emphasis was laid on planning a balanced growth of the department in different areas of Mathematics and Statistics.

Prof. Pai's research work is mainly in the areas of functional analysis and approximation theory. His current interests in this domain mostly concern approximation of vector-valued functions, and stability and well-posedness aspects in approximation and optimization.

Prof. Pai has authored/co-authored over fifty research articles in international/national journals of repute, contributed numerous articles in the proceedings of international/national conferences and guided several students for their Ph.D. degree. Along with Prof. H.N. Mhaskar of California State University, Los Angeles, USA, he has authored a book entitled Fundamentals of Approximation Theory in 2000, which was recently revised in 2007. He has held a number of visiting positions as well as given many invited lectures in North America, Europe and the Middle East. He also had the opportunity of visiting several universities in France and giving talks in their Group Seminars under a scheme of INSA-Academy of Sciences, Paris.

At present, Prof. Pai is on the editorial board of the Asian European Journal of Mathematics. He has worked as a member in many Government of India Committees on Mathematical Sciences such as the Programme Advisory Committee (PAC-MS) of SERC, DST, PMMC committees of DST and UGC Advisory Committees, among others. He also worked as a member of the Scientific Committee of the Indo-French Institute of Mathematics.

He received the Excellence in Teaching award in 2000. Prof. Pai has also been conferred the title Professor Emeritus by IIT Bombay.

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SEPTEMBER 2009 Centre for Distance Engineering Education Programme

A NEWSLETTER OF CDEEP, IIT BOMBAY
http://www.cdeep.iitb.ac.in

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MHRD Sponsored Projects of IIT Bombay
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Revolutionizing the Open Source Movement in India

Computing has changed the way we learn and practice science and engineering. Clearly, the effective use of computers is beneficial for students. However, we often find that students are unable to properly perform simple computing tasks such as writing good code, carrying out simple numerical analysis, generating plots and presenting a polished document that includes equations. They are also not trained in good software engineering practices. In effect, students do not fully harness the capabilities of the modern computer.

Students mostly use commercial software packages like Matlab and Mathematica. While these are suitable for the engineering and research community, these packages are extremely expensive. Even the IITs cannot afford to equip a lab with such software for all students, let alone provide the software for work outside the lab. This is totally unacceptable as it is akin to providing students with books that they cannot read outside the classroom!

The same affordability problems apply to smaller companies too. When our students join such organizations, they find that they are unable to fully deploy the skills and knowledge they have acquired without resorting to unacceptable options. Unfortunately, many are unaware of the best combination of open source software for engineering and scientific computing that can mitigate these problems to a very great extent. It is therefore imperative to teach students good open source software tools, techniques and practices.

The MHRD funded FOSSEE project (http://fossee.in) aims to address several of these concerns. We plan to encourage the adoption of free and open source tools in science and engineering education all over India. Currently, we are focussing on Python and Scilab.

Scilab (www.scilab.org) is a powerful, free, alternative to Matlab that can be used in a wide variety of numerical computing tasks.

Python (www.python.org) is a free, programming language that is very easy to learn, yet versatile and powerful. Organizations like Google and NASA use it heavily. Python has libraries that are ideal for numerics (www.scipy.org), symbolic computing (www.sagemath.org) and data visualization. Python interfaces well with C, C++ and FORTRAN. It provides a rich suite of general purpose libraries for generating user interfaces, web development, network programming, etc. Coupled with its interactive Interpreter, Python is an excellent language for scientific computing.

We plan to conduct a course on software tools, techniques and practices (STTP) that teaches students the elements of software engineering including version control and test driven development, along with basic and advanced Python necessary for engineering computations.

On completion of this course, students will be able to solve non-trivial scientific computing problems, produce professional looking documents and write clean code using good software engineering practices. This course is likely to be introduced next semester at IIT Bombay. Later, an advanced course on Numeric and Symbolic Computation with Python is planned.

Several free workshops (more than ten before the end of 2009) shall be conducted on both Python and Scilab at various places all over India for both teachers and students. The material will also be available as an e-learning course that students can learn from the web. At present, we are looking into how to provide certification for students successfully completing the web-based courses.

We will be generating and collecting documentation, books and spoken tutorials to ease the adoption of this material. We have already bundled and made available the required software free of charge on DVDs. We also plan to help faculty members convert existing courses that use commercial code to FOSS equivalents.

For more details visit http://fossee.in or write to info@fossee.in.

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SHARING KNOWLEDGE THROUGH THE CDEEP GATEWAY

Sharing knowledge is not about giving people something, or getting something from them. Sharing knowledge occurs when people are genuinely interested in helping one another develop new capacities for action; it is about creating learning processes. The development of technology that facilitate such sharing of knowledge with students located in geographically distant areas and the marshalling of knowledge resources for this purpose has been the hallmark of CDEEP's success. IIT Bombay has the best pool of expert and dedicated engineering and science faculty among leading technical educational institutions in our country. Such an initiative is needed to share the expertise available so that a maximum number of students benefit across the nation.

The R C Patel Institute of Technology (RCPIT), Shirpur, takes pride in being associated with the best institutions. We are thankful to CDEEP for helping us share and take part in transmitted classroom lectures from IIT Bombay. RCPIT provides the best infrastructural and educational facilities to its students. It is thus possible to connect to CDEEP through our EDUSAT terminal and also watch the live webcasts of the lectures. The audio and video clarity of these lectures is good.

All our students and faculty members are taking advantage of these lectures in order to develop their knowledge base. Specifically, 102 students of B.E. and 24 instructors have been participating in a more focused manner. These participants are encouraged to attend all the lectures and they especially like the interaction with the instructor at IIT Bombay that is provided in this programme. The feedback from these participants is so inspiring that we plan to include nearby technical and science institutions so as to establish a broader knowledge network.

While CDEEP is trying its best to provide content delivery that matches learning needs, we feel that there should be additional sessions or even a whole new programme that will inspire participants in the direction of research. We at RCPIT wish CDEEP the best and we hope that this program reaches out to every corner of the world.

Dr. P. J. Deore
CDEEP Coordinator
R C Patel Institute of Technology, Shirpur

CDEEP'S RECORDED COURSES

Given below is the concluding part of the list of classroom courses of IIT Bombay that have so far been recorded through CDEEP. Of course, every semester we continue to record classroom courses and these will get added to this list.

No.	Course name	Course Instructor	Discipline
88.	Geomorphology & Remote Sensing	Prof. Subramaniam Iyer	
89.	Medical Physics	Prof. A.S. Mahajan	
90.	Visualization & Imaging	Prof.U. A. Athavankar	
91.	Digital Systems	Prof. A. N. Chandorkar	
92.	Microfluidics	Prof. Amit Agrawal	
93.	Advanced Methods in Satellite Image Processing	Prof. B. K. Mohan	
94.	Thermodynamics of Polymeric System	Prof. Hemant Nanavati	
95.	Analog Circuits	Prof. Jayanta Mukherjee	
96.	Systems Design	Prof. M. P. Desai	
97.	VLSI Design Lab	Prof. M. Shojaei Baghini	
98.	Optimization	Prof. P. S. V. Nataraj	
99.	Molecular Biophysics	Prof. P. V. Balaji	
101.	Computational Biology	Prof. Pramod Wangikar	
102.	Advanced Process Control	Prof. R. Gudi	
103.	Introduction to Quantum Mechanics	Prof. Raghava Varma	
104.	Digital Protection of Power Systems	Prof. S. A. Soman	
105.	Digital Communication Systems	Prof. S. N. Merchant	
106.	Quantum Mechanics II	Prof. S. Umasankar	
107.	Signals and Systems	Prof. U. B. Desai	
108.	Physical and Stochastic Hydrology	Prof. V. Jothiprakash	
109.	Control Systems	Prof. V. Kulkarni	
110.	Introduction to Quantum Physics		
111.	Chemistry I		
112.	Mechanics of Solids		
113.	Univariate and Multivariate Calculus	Prof. K. D. Joshi and Prof. D.V. Pai	
114.	Analog and Mixed Signal Design and VLSI Design		
115.	Linear Algebra	Prof. M. Srinivasan	
116.	Differential Equation	Prof. Gopal Srinivasan	
117.	Differential Equation II	Prof. Gopal Srinivasan	
118.	Complex Analysis	Prof. Neela Nataraj	

COURSES FOR YOU

Aircraft Design (AE 332)

In recent years, many aircraft design and development projects have been initiated in India. These include the Light Combat Aircraft, the Intermediate Jet Trainer, Hansa, Saras and the Regional Transport Aircraft. Thus, the development of trained manpower in the area of aircraft design is of paramount importance.

Aircraft Design aims to provide an exposure to aircraft design and will focus on conceptual design aspects. The content consists of six modules:(i)Introduction to aircraft design;(ii) Configuration and layout;(iii)Sizing and constraint analysis; (iv) Refined sizing and estimation methodologies; (v) Operational and environmental issues and (vi)Advanced concepts in aircraft design.

Participants will be provided an overview of various types of aircraft and how the requirements specified by customers and certification agencies affect the selection of their configurations and layout. Methodologies for carrying out quick back-of-the-envelope calculations, as well as more detailed estimates for sizing an aircraft will be taught. An overview of some operational and environmental issues such as noise and emissions will also be provided. Design principles will be elucidated through description of some case studies related to existing aircraft.

Hands-on experience will be provided through assignments and worked examples. Current developments and research areas such as blended wing-body, configuration morphing and multi-disciplinary design optimization will also be covered. Although the course will primarily focus on fixed winged aircraft, a brief overview of key issues and challenges faced during the design of other heavier-and lighter-than-air vehicles will also be provided.

This course is appropriate for students in the third or fourth year of an undergraduate program in Aeronautical or Mechanical Engineering, or a postgraduate program in these branches. Students from other branches may also benefit, provided they have some basic exposure to fluid and structural mechanics.

Aircraft Design will be offered under the aegis of CDEEP, IIT Bombay, in the forthcoming spring semester (January-April 2010). Colleges interested in receiving this course may contact CDEEP at cdeep@iitb.ac.in

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USEFUL LINKS

IIT Bombay homepage	: http://www.iitb.ac.in
Web address of CDEEP	: http://www.cdeep.iitb.ac.in
Web address of NPTEL	: http://www.nptel.iitm.ac.in
All Courses of IIT Bombay	: http://www.iitb.ac.in/acadpublic/Course.html
Live Webcast Courses	: http://www.cdeep.iitb.ac.in/solo
National Mission on Education	: http://www.sakshat.ac.in

SPOKEN TUTORIALS

One of IIT Bombay's projects sponsored by the National Mission on Education through ICT is supporting the creation of open source software (see the May issue of Reach Out for details). Although commercial software is very expensive, free and open source software is still not being used widely, one reason being inadequate documentation. Through spoken tutorials, one can create outstanding documentation, making open source software easily accessible.

A spoken tutorial explains a computer-based activity, step by step, along with a live demonstration of it in parallel. The tutorial captures the changes in the screen in the form of a movie, along with a running commentary by an expert. The following steps are needed to create a spoken tutorial: i) Choose the software to be explained through the tutorial; ii) Construct one or more examples that will help demonstrate the above software; iii) Create a script that pins down the sequence of activities and the accompanying explanation; iv) Choose a software that captures the activities on the screen in the form of a video with an ability to record the accompanying voice input; v) Use an editing program that can trim and polish the video file obtained in the previous step; vi) Suppress the audio and superimpose a running commentary in the desired language. A sample of these tutorials is available at www.moudgalya.org, under the link LaTeX tutorials.

There are many benefits, both pedagogical and socioeconomic, in using spoken tutorials. Listening to directions given by a person experienced in using a particular software is always better than ploughing through written instructions. The student can see the cursor movement accompanied by the spoken explanation and can pause, rewind and play it again for better understanding. Also, the student can try the target software in parallel, as she listens to the spoken tutorial and is therefore not just a passive observer.

The file size of a spoken tutorial is much smaller than that of a video recording, resulting in benefits such as small storage size and small bandwidth for streaming. Also, the infrastructure (head phone with audio input, screen capture software) required to create a spoken tutorial is free or inexpensive. Some software packages that capture the screen in a video file are *CamStudio, xvidcap, jing* and *iShowU*.

As the required infrastructure is minimal, a large number of people can create such tutorials, even for the most complicated programs. Since the running commentary can be in a local language, this potentially can reduce the digital divide between urban and rural India.

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