PIC *Live*:
Real-time interactive programming in scientific simulation

Ben Swift
Andrew Sorensen
Henry Gardner

Australian National University

Viktor K Decyk

University of California, Los Angeles

32
88
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77
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SCF Frontiers: towards exascale…

we’re doing it **all wrong!**

but we're here at the frontier, we're optimistic—we have ideas about how to make things better

in that context: this is real-time interactive programming in scientific simulation

Outline

a **tool**: the Extempore programming language/ environment

a **demonstration**: live programming a particle-in-cell (PIC) plasma physics simulation

a **discussion**: what use (if any) is "liveness" in computational and simulation science?

(lisp)

COMPUTING

Computer programming

Learn how to program drawings, animations, and games using JavaScript & ProcessingJS, or learn how to create webpages with HTML & CSS. You can share whatever you create, explore what others have created and learn from each other!

Create:

- New Program (JS + ProcessingJS)
- New Webpage
- New SQL script

Browse Creations

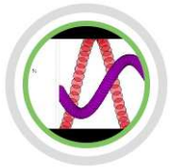
Help Requests

Intro to JS: Drawing & Animation

In these tutorials, you'll learn how to use the JavaScript language and the ProcessingJS library to create fun drawings and animations. If you've never programmed before, start here to learn how!

Advanced JS: Games & Visualizations

Now that you know how to program in JavaScript and make basic drawings and animations, how could you use that knowledge to make games and visualizations?



Advanced JS: Natural Simulations

Learn how to use JavaScript, ProcessingJS, and mathematical concepts to simulate nature in your programs. These tutorials are a derivative of "The Nature of Code" book by Daniel Shiffman (natureofcode.com), used under CC BY-NC.

HTML/CSS: Making webpages

Learn how to use HTML and CSS to make webpages. HTML is the markup language that you surround content with and it tells the browser about the parts of your page like headings, lists, and tables. CSS is the stylesheet language that you style the page with, which tells the browser to change the color, font, layout, and more.

Interactive (live) programming

tight feedback loop between programmer **action** and system **reaction**, between **intuition** and **validation**

not so common in HPC (for a variety of socio-technical reasons) although people are starting to talk about real-time/online—streaming, in-situ analysis etc.

extempore

a programming language & runtime environment

interactive: JIT-compiled on node to native code using LLVM

subroutines can be hot-swapped, even in tight loops

eval/update code while the program is running, on one or many nodes

open source (MIT): https://github.com/digego/extempore

But our codes work pretty well...

extempore is ABI compatible with C/Fortran, so you can

- call compiled C/Fortran routines from a shared library

- read and write directly to memory (pointers)

- use e.g. MPI for message passing, OpenMP for threading

*...all with **live** hot-swapping*

Live PIC: a case study

2½D electromagnetic PIC skeleton code

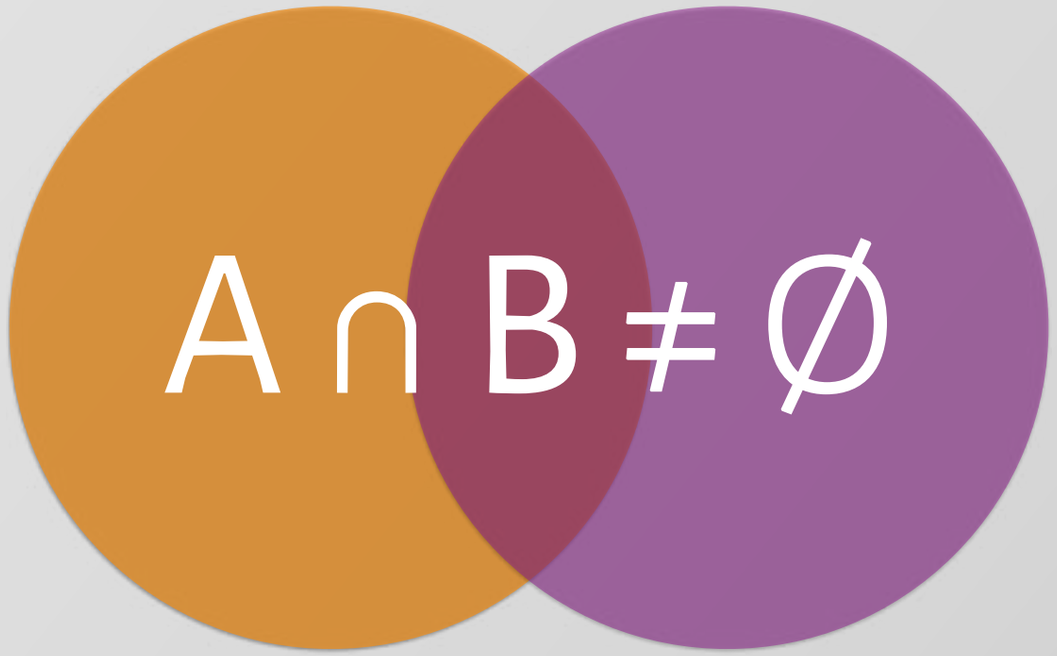
running **live**, distributed memory (MPI)

on my laptop (for practical reasons) but could be on a cluster

visualisation code also live, running on head node

demo

When might you want to do this?



you're not sure *exactly* what you're looking for

you can't afford to dump *everything* to disk for later post-processing

Why might you want to do this?

parameter space exploration (e.g. finding the right beam shape)

in-situ & in-transit analysis

stopping conditions/convergence properties are obvious to a (human) domain expert, but nontrivial to encode in an algorithm

many-worlds: multiple concurrent simulations, make different changes to each, view diffs

smaller development cluster

Challenges

safety (the Peter Parker principle)

reproducibility (and provenance)

“stage fright”

Image: Art--Surgery

allowing scientists to get **intimate** with their codes

Morpho eugenia
Guyana

Morpho melacheilus
Peru

Morpho rhetenor
French Guiana

Morpho godarti
Bolivia

Morpho achi
Brasil

Morpho caterna
Brasil

Morpho cypris
Colombia

orpho helenor
Peru

Morpho an
Brasil

Morpho adonis
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Peru

ho sulkowskyi
Colombia

ben.swift@anu.edu.au

https://github.com/digego/extempore

http://benswift.me/extempore-docs

#extempore on freenode