Entry Points to Visualization: Different Methods for Different Problems

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University of British Columbia

Viz@UBC Kickoff: Lunchtime Lecture Series
12 March 2019

www.cs.ubc.ca/~tmm/talks.html#vizatubc19-entry

@tamaramunzner
Visualization (vis) defined & motivated

Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

Visualization is suitable when there is a need to augment human capabilities rather than replace people with computational decision-making methods.

• human in the loop needs details about data
  – entry point: exploratory data analysis
  • don't know exactly what questions to ask in advance
  – entry point: presentation of known results
  – entry point: interplay with automation
  • refining model, trustbuilding/monitoring, mixed-initiative

• external representation: perception vs cognition

• intended task, measurable definitions of effectiveness

more at:
Visualization Analysis and Design, Chapter 1.
Analysis framework: Four levels, three questions

- **domain situation**
  - who are the target users?

- **abstraction**
  - translate from specifics of domain to vocabulary of visualization
    - **what** is shown? **data** abstraction
    - **why** is the user looking at it? **task** abstraction

- **idiom**
  - **how** is it shown?
    - **visual encoding** idiom: how to draw
    - **interaction** idiom: how to manipulate

- **algorithm**
  - efficient computation

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Different threats to validity at each level

- cascading effects downstream

- Domain situation
  - You misunderstood their needs

- Data/task abstraction
  - You're showing them the wrong thing

- Visual encoding/interaction idiom
  - The way you show it doesn't work

- Algorithm
  - Your code is too slow
Different methods for different problems, from different fields

- interdisciplinary, mix of qual and quant approaches (typically)

- **anthropology/ethnography**
  - **Domain situation**
    - Observe target users using existing tools
  - **Data/task abstraction**
    - **Visual encoding/interaction idiom**
      - Justify design with respect to alternatives
    - **Algorithm**
      - Measure system time/memory
      - Analyze computational complexity
  - Analyze results qualitatively
  - Measure human time with lab experiment (lab study)
  - Observe target users after deployment (field study)

- **design**
  - **Domain situation**
    - Observe target users using existing tools
  - **Data/task abstraction**
    - **Visual encoding/interaction idiom**
      - Justify design with respect to alternatives
  - Analyze results qualitatively
  - Measure human time with lab experiment (lab study)

- **computer science**
  - **Domain situation**
    - Observe target users using existing tools
  - **Data/task abstraction**
    - **Algorithm**
      - Measure system time/memory
      - Analyze computational complexity

- **psychology**
  - **Domain situation**
    - Observe target users using existing tools
  - **Data/task abstraction**
    - **Algorithm**
      - Measure system time/memory
      - Analyze computational complexity

- **anthropology/ethnography**
  - **Domain situation**
    - Observe target users using existing tools
  - **Data/task abstraction**
    - **Algorithm**
      - Measure system time/memory
      - Analyze computational complexity

---

Method mismatches: Common problem

- **Domain situation**
  Observe target users using existing tools

- **Data/task abstraction**
  - Visual encoding/interaction idiom
    Justify design with respect to alternatives
  - Algorithm
    Measure system time/memory
    Analyze computational complexity
  - Analyze results qualitatively
  - Measure human time with lab experiment (*lab study*)
  - Observe target users after deployment (*field study*)
  - Measure adoption

lab studies can't confirm task abstraction

benchmarks can't confirm design

Analysis examples: Single paper includes only subset of methods

- observe and interview target users
- justify encoding/interaction design
- measure system time/memory
- qualitative result image analysis

- observe and interview target users
- justify encoding/interaction design
- qualitative result image analysis
- field study, document deployed usage

An energy model for visual graph clustering. (LinLog) Noack. Graph Drawing 2003
- qualitative/quantitative image analysis

- lab study, measure time/errors for operation

- justify encoding/interaction design
- qualitative result image analysis
- test on target users, get utility anecdotes

- justify encoding/interaction design
- computational complexity analysis
- measure system time/memory
- qualitative result image analysis
Different angles of attack for different problems

- Technique-driven work
- Problem-driven work
- Theoretical foundations
- Evaluation
Technique-driven work

• scalable algorithms & systems
  – typical evaluation: computational benchmarks

• new layout & interaction techniques
  – typical evaluation: usage scenarios
  – typical evaluation/characterization: controlled experiments on human subjects
Technique-driven: Graph/network drawing

Daniel Archambault  
David Auber (Bordeaux)

https://youtu.be/AWX Ae8zykt8

TopoLayout  
SPF  
Grouse  
GrouseFlocks  
TugGraph

Benjamin Renoust  
Guy Melançon (Bordeaux)

Detangler  
https://youtu.be/QOtnHSsUV6k
Technique-driven: Tree drawing

Zipeng Liu

Shing Hei Zhan

Aggregated Dendrograms

https://youtu.be/2SLcz7KNLJw

TreeJuxtaposer

https://youtu.be/GdaPj8a9QEo
Evaluation experiments: Graph/tree drawing

Dmitry Nekrasovski  
Adam Bodnar  
Joanna McGrenere

Search set model of path tracing

Stretch and squish navigation

Jessica Dawson  
Joanna McGrenere

Lab study led to “focus+context” idiom disenchantment

1. Qualitative study: coding observational video
2. Create & implement behavioral model
3. Multiple regression to untangle factor relationships
Technique-driven: Dimensionality reduction

Stephen Ingram

Glimmer

Glint

DimStiller

QSNE
Dimensionality reduction for documents

• derive low-dimensional target space from high-dimensional measured space
Evaluation experiments: Dimensionality reduction

Michael Sedlmair  Melanie Tory

traditional user study:
many people for short time,
few datasets

data studies: many datasets, few people for long time (experts qual+quant coding)

Guidance on DR & scatterplot choices

Taxonomy of cluster separation factors
Evaluation in the field: Dimensionality reduction

DR in the Wild

interview study & qualitative
coding led to task abstractions:
specific to data type,
agnostic to domain

Matt Brehmer  Michael Sedlmair  Melanie Tory  Stephen Ingram
Problem-driven work

• "design studies"
  – in collaboration with target users
    • real data, real tasks
    • intensive requirements analysis
  – iterative refinement
    • deploy tools/systems
  – typical evaluation: field studies

• my strategy: opportunistic collaboration
  – many domains
  – both industrial and academic partners
Problem-driven: Genomics

Aaron Barsky (Microbio)  
Jenn Gardy (Microbio)  
Robert Kincaid (Agilent)

Miriah Meyer (Harvard)  
Hanspeter Pfister (Harvard)

Cerebral  
https://youtu.be/76HhG1FQngI

MizBee  
https://youtu.be/86p7brwuz2q

MulteeSum, Pathline
Problem-driven: Genomics, fisheries

Joel Ferstay (BC Cancer)

Cydney Nielsen (BC Cancer)

Variant View
https://youtu.be/AHDnv_qMXxQ

Maryam Booshehrian

Torsten Moeller (SFU)

Vismon
https://youtu.be/h0kHoS4VYmk
Problem-driven: Tech industry

Heidi Lam
(Google)

Diane Tang

Stephen North
(AT&T Research)

SessionViewer: web log analysis
https://youtu.be/T4MaTZd56G4

methods reflection: staged model of access to target users

LiveRAC: systems time-series
https://youtu.be/ld0c3H0VSkw
Problem-driven: Building energy mgmt, journalism

Kevin Tate
(Pulse/EnerNOC)

redesign success:
industrial swdev
resources committed

Jonathan Stray
(Assoc Press)

Matt Brehmer
Stephen Ingram

https://vimeo.com/71483614
Overview: The Design, Adoption, and Analysis of a Visual Document Mining Tool For Investigative Journalists.

http://www.cs.ubc.ca/labs/imager/tr/2014/Overview/

https://www.overviewdocs.com
<table>
<thead>
<tr>
<th>Case Study</th>
<th>#1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document Collection</td>
<td>4,500 pages from FOIA</td>
</tr>
<tr>
<td>Question</td>
<td>What did security contractors do during Iraq war?</td>
</tr>
</tbody>
</table>

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<tr>
<th>Question</th>
<th>Were municipal police funds mismanaged?</th>
</tr>
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<td>Question</td>
<td>Was gov't response to emergency incident effective?</td>
</tr>
<tr>
<td>Question</td>
<td>Did gov't fail to pass bills addressing police misconduct?</td>
</tr>
</tbody>
</table>
## Case Study

<table>
<thead>
<tr>
<th>Question</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
</tr>
</thead>
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<tr>
<td>Document Collection</td>
<td>4,500 pages from FOIA</td>
<td>5,996 emails from FOIA</td>
<td>8,680 pages from FOIA</td>
<td>1,278 survey comments</td>
<td>4,653 emails from FOIA</td>
<td>1,680 bills</td>
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… to redesign, to reflect on task abstractions…

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<td>Did gov’t fail to pass bills addressing police misconduct?</td>
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</tbody>
</table>
THOUSANDS OF DOCUMENTS
Problem-driven: In-car networks, e-commerce

Michael Sedlmair
RelEx (BMW)
https://youtu.be/89lsQXc6Ao4

Kim Dextras-Romagnino

latest work: Segmentifier (Mobify): e-commerce clickstreams
sneak preview video
Segmentifier: Interactively Refining Clickstream Data into Actionable Segments
Theoretical foundations: Methodology

Nested Model

- Visual Encoding Pitfalls
  - Unjustified Visual Encoding
  - Hammer In Search Of Nail
  - 2D Good, 3D Better
  - Color Cacophony
  - Rainbows Just Like In The Sky

- Strategy Pitfalls
  - What I Did Over My Summer
  - Least Publishable Unit
  - Dense As Plutonium
  - Bad Slice and Dice

Papers Process & Pitfalls

Anamaria Crisan

Michael Sedlmair

Miriah Meyer

Design Study Methodology

Regulatory & Organizational Constraints
Design Study Methodology

Reflections from the Trenches and from the Stacks

http://www.cs.ubc.ca/labs/imager/tr/2012/dsm/

Methodology for problem-driven work

• definitions

• 9-stage framework

• 32 pitfalls & how to avoid them

• comparison to related methodologies
Lessons learned from the trenches: 21 between us

- Cerebral genomics
- MizBee genomics
- Pathline genomics
- MulteeSum genomics
- Vismon fisheries management
- QuestVis sustainability
- WiKeVis in-car networks
- MostVis in-car networks
- Car-X-Ray in-car networks
- ProgSpy2010 in-car networks
- RelEx in-car networks
- Cardiogram in-car networks
- AutobahnVis in-car networks
- VisTra in-car networks
- Constellation linguistics
- LibVis cultural heritage
- Caidants multicast
- SessionViewer web log analysis
- LiveRAC server hosting
- PowerSetViewer data mining
- LastHistory music listening
Design study methodology: definitions

- **TASK CLARITY**
  - crisp
  - fuzzy

- **INFORMATION LOCATION**
  - head
  - computer

- **ALGORITHM AUTOMATION POSSIBLE**

- **NOT ENOUGH DATA**

- **DESIGN STUDY METHODOLOGY SUITABLE**
9 stage framework

PRECONDITION

CORE

ANALYSIS

learn → winnow → cast → discover → design → implement → deploy → reflect → write
9-stage framework

PRECONDITION

CORE

ANALYSIS

learn
winnow
cast

learn
winnow
cast

discover → design → implement → deploy → reflect → write
9-stage framework

discover
design
implement
deploy

PRECONDITION

CORE

ANALYSIS
9-stage framework

- guidelines: confirm, refine, reject, propose
9-stage framework

PRECONDITION

CORE

ANALYSIS

iterative
and practice within the culture using methods that include observation methodology in HCI [16, 29, 30]. Traditional ethnography in minology from these methodologies to buttress a key claim on how to tics in HCI with similar qualitative intentions. We also use the ter- we now compare design study methodology to influential methodolo-

design study methodology: 32 pitfalls

<table>
<thead>
<tr>
<th>Pitfall ID</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF-1</td>
<td>Premature advance: jumping forward over stages</td>
<td>General</td>
</tr>
<tr>
<td>PF-2</td>
<td>Premature start: insufficient knowledge of visualization literature</td>
<td>Learn</td>
</tr>
<tr>
<td>PF-3</td>
<td>Premature commitment: collaboration with wrong people</td>
<td>Winnow</td>
</tr>
<tr>
<td>PF-4</td>
<td>No real data available (yet)</td>
<td>Winnow</td>
</tr>
<tr>
<td>PF-5</td>
<td>Insufficient time available from potential collaborators</td>
<td>Winnow</td>
</tr>
<tr>
<td>PF-6</td>
<td>No need for visualization: problem can be automated</td>
<td>Winnow</td>
</tr>
<tr>
<td>PF-7</td>
<td>Researcher expertise does not match domain problem</td>
<td>Winnow</td>
</tr>
<tr>
<td>PF-8</td>
<td>No need for research: engineering vs. research project</td>
<td>Winnow</td>
</tr>
<tr>
<td>PF-9</td>
<td>No need for change: existing tools are good enough</td>
<td>Winnow</td>
</tr>
</tbody>
</table>
I’m a domain expert! Wanna collaborate?

Of course!!!
considerations

Have data? Have time? Have need? ...

Interesting problem?
### Design study methodology: 32 pitfalls

<table>
<thead>
<tr>
<th>PF-21</th>
<th>mistaking technique-driven for problem-driven work</th>
<th>design</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF-22</td>
<td>nonrapid prototyping</td>
<td>implement</td>
</tr>
<tr>
<td>PF-23</td>
<td>usability: too little / too much</td>
<td>implement</td>
</tr>
<tr>
<td>PF-24</td>
<td>premature end: insufficient deploy time built into schedule</td>
<td>deploy</td>
</tr>
<tr>
<td>PF-25</td>
<td>usage study not case study: non-real task/data/user</td>
<td>deploy</td>
</tr>
<tr>
<td>PF-26</td>
<td><em>liking</em> necessary but not sufficient for validation</td>
<td>deploy</td>
</tr>
<tr>
<td>PF-27</td>
<td>failing to improve guidelines: confirm, refine, reject, propose</td>
<td>reflect</td>
</tr>
<tr>
<td>PF-28</td>
<td>insufficient writing time built into schedule</td>
<td>write</td>
</tr>
<tr>
<td>PF-29</td>
<td>no technique contribution ≠ good design study</td>
<td>write</td>
</tr>
<tr>
<td>PF-30</td>
<td>too much domain background in paper</td>
<td>write</td>
</tr>
<tr>
<td>PF-31</td>
<td>story told chronologically vs. focus on final results</td>
<td>write</td>
</tr>
<tr>
<td>PF-32</td>
<td>premature end: win race vs. practice music for debut</td>
<td>write</td>
</tr>
</tbody>
</table>
Horse Race vs. Music Debut

Must be first!

Am I ready?

technique-driven

problem-driven

http://www.alaineknipes.com/interests/violin_concert.jpg

EXAMPLE FROM THE TRENCHES
Don’t step on your own toes!

First design round published

Subsequent work not stand-alone paper

AutobahnVis 1.0
[Sedlmair et al., Smart Graphics, 2009]

AutobahnVis 2.0
[Sedlmair et al., Information Visualization 10(3), 2011]
Theoretical foundations: Typologies

Abstract Tasks

GEViT: Genomic Epidemiology Visualization Typology

Regulatory & Organizational Constraints

Matt Brehmer

Anamaria Crisan
Curation & Presentation: Timelines

**TimeLineCurator**
https://vimeo.com/123246662

**Timelines Revisited**
timelinesrevisited.github.io/

Matt Brehmer

Johanna Fulda
(Sud. Zeitung)

Matt Brehmer

Bongshin Lee
(Microsoft)

Benjamin Bach
(Microsoft)

Nathalie Henry-Riche
Interactive Authoring of Visual Timelines from Unstructured Text

TimeLineCurator: Interactive Authoring of Visual Timelines from Unstructured Text.
Structured creation process

- Browse
- Extract
- Format
- Show
- Update

TimelineJS
timeline.knightlab.com/
### Timeline authoring model

- time required for each task

<table>
<thead>
<tr>
<th></th>
<th>Browse</th>
<th>Extract</th>
<th>Format</th>
<th>Show</th>
<th>Update</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manual Drawing</strong></td>
<td>slow</td>
<td>slow</td>
<td>slow</td>
<td>slow</td>
<td>slow</td>
</tr>
<tr>
<td><strong>Structured Creation</strong></td>
<td>slow</td>
<td>slow</td>
<td>slow</td>
<td>automated</td>
<td>fast</td>
</tr>
<tr>
<td><strong>TimeLine Curator</strong></td>
<td>fast</td>
<td>automated</td>
<td>automated</td>
<td>fast</td>
<td>fast</td>
</tr>
</tbody>
</table>
The general case for curation

- build for human in the loop as continuing need
  - automatic processing to accelerate not replace
  - assume computational results good but not perfect
    - for the indefinite future!
- visual feedback to accelerate
The importance of being brisk

• sexy use case: eureka moment
  – success: enable what was impossible before
  – vis tools for new insights & discoveries

• workhorse use case: workflow speedup
  – success: vis tools accelerate your prior workflow
  • sometimes enables the previously infeasible

• TLC use cases
  – started with speedup use case, for presentation
    • make this doc into a timeline now!
  – two other use cases nudge towards exploration
    • comparison between multiple timelines
    • speculative browsing
TimeLineCurator: Speculative Browsing

https://vimeo.com/jofu/tlc
Curation & Presentation: Timelines

TimeLineCurator
https://vimeo.com/123246662

Timelines Revisited
timelinesrevisited.github.io/
Presentation: Geometry Center math vis videos

Outside In

The Shape of Space

Stuart Levy

Mark Phillips

Delle Maxwell
Visualization entry points

• goals
  – exploratory data analysis
  – presentation
  – curation / authoring

• methods
  – algorithm development
  – system building & software development
  – lab studies with human subjects
  – field studies with human subjects
Teaching
Visualization Analysis and Design

• book page
  
  http://www.cs.ubc.ca/~tmm/vadbook

  – 20% promo code for book+ebook combo: HVN17


  – free to read online within UBC
    http://resolve.library.ubc.ca/cgi-bin/catsearch?bid=7678980

• slide decks at many talk lengths (1, 2, 3, 6, 8+ hrs), some w/ videos
  
  http://www.cs.ubc.ca/~tmm/talks.html#vadallslides
Visualization Analysis & Design

IEEE VIS 2014 Tutorial Video Preview

Tamara Munzner
Department of Computer Science
University of British Columbia
Analyse

Data Types

→ Items
→ Attributes

Data and Dataset Types

→ Tables
→ Networks
→ Items
→ Attributes

Dataset Types

→ Tables

Search

→ Multi-dimensional Table

Query

→ Identify
→ Compare
→ Summarize

Spatial Data

→ Shape

Encode

→ Arrange
→ Express
→ Separate

→ Order
→ Align

Map

→ from categorical and ordered attributes

→ Color
→ Hue
→ Saturation
→ Luminance

→ Size, Angle, Curvature, ...

→ Shape
→ Motion
→ Direction, Rate, Frequency, ...

Manipulate

→ Change
→ Juxtapose

→ Select
→ Partition

→ Navigate
→ Aggregate

→ Filter

Facet

→ Superimpose

Reduce

→ Embed

What?

Data Sets
→ Attributes
→ Data Types
→ Dataset Types

Why?

→ Why?

→ How?

→ What?

How?

→ Encode
→ Map
→ Manipulate
→ Reduce
→ Facet

→ Why?

→ How?

→ What?
How to handle complexity: 4 families of strategies

Derive

- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view

Manipulate

- Change
- Select
- Navigate

Facet

- Juxtapose
- Partition
- Superimpose

Reduce

- Filter
- Aggregate
- Embed
Visualization Teaching at UBC: Me

• Computer Science grad
  – open to all students, no CS prereqs, non-programming project options available
  – tooling not taught (most use D3 or R)

• Computer Science ugrad
  – coming in January 2020, 4th year CS majors
  – tooling: D3

• Data Science
  – tooling: R

• Journalism
  – tooling: Tableau

• Ed Psych, Forestry, Geography, iSchool, Psychology
  https://dfp.ubc.ca/initiatives/viz-ubc/visualization-courses
Visualization Teaching Across UBC

• many other visualization-focused courses
  – Ed Psych
  – Forestry
  – Geography
  – iSchool
  – Psychology

• initial list compiled
  https://dfp.ubc.ca/initiatives/viz-ubc/visualization-courses
  – please contact vizatubc-info@cs.ubc.ca with additions/corrections!

• still todo: compile list of courses with significant visualization content
Engaging with visualization teaching

- teach/take a visualization-focused course
- teach/take domain-oriented course where visualization plays a role
  - presentation
  - exploratory data analysis
- offer your domain problem as project topic
  - research or administrative data
Engaging: Possible Next Steps
Redesign En Masse: **Makeover Mondays**

- easy entry point, Tableau focus

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**Week 14 – Millions of UK workers at risk of being replaced by robots**

Apr 7, 2017

During week 14 we looked at job automation and the potential impact of robots and AI on the UK employment market.

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**Week 13 – The Secret of Success**

Mar 31, 2017

Week 13 took a look at a Russian survey about the secret of success. Dot plot, bump charts, bar charts, radar charts. This week had it all! Plus seven lessons to take on board.

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**Week 12 – March Madness**

Mar 24, 2017

We looked at March Madness data for week 12, highlighting the phenomenon that is US college basketball. Quite a few vizzes showed the passion that

http://www.makeovermonday.co.uk/blog/
Visual Design Process In Depth: **Dear Data**

- inspiring celebration of data humanism

http://www.dear-data.com/by-week/  Giorgia Lupi and Stefanie Posavec
Visual Design Process In Depth: **Data Sketches**

- detailed process notes, from sketching through coding

http://www.datasketch.es/

Shirley Wu and Nadieh Brehmer
Pathways to participate

• join Viz@UBC
  – https://dfp.ubc.ca/initiatives/viz-ubc
  – get on visatubc-announce email list (send mail to vizatubc-info@cs.ubc.ca)
  – upcoming kickoff events: 2 more talks + 1 mixer
  – join as core, so you're findable in people index
  – join as organizer, help us decide what to do next

• join Data Visualization Society
  – https://www.datavisualizationsociety.com/
  – brand new! resources, jobs board,...
Pathways to participate

• participate in IEEE VIS 2019 in Vancouver, Oct 20-25
  –http://ieeevis.org
  –big 3 research tracks: VA, InfoVis, SciVis
  –many associated events
    • Vis in Data Science
    • Vis In Practice
    • Large Data Analysis & Visualization
    • Application Spotlights
    • many workshops including bio, security, ...
  –job fair (asynchronous)
More Information

• this talk
  https://www.cs.ubc.ca/~tmm/talks.html#vizatubc19-entry

• papers, videos, software, talks, courses
  http://www.cs.ubc.ca/group/infovis
  http://www.cs.ubc.ca/~tmm

@tamaramunzner
Q&A References

• entry points for practitioners?
  – D3 resources for advanced programmers:
    https://bl.ocks.org/
  – R resources for range of programming experience:
    https://www.tidyverse.org/
    https://ggplot2.tidyverse.org/
  – Tableau resources, for non-programmers:
    https://www.tableau.com/
  – Andy Kirk's continuously updated resources list
    http://www.visualisingdata.com/resources/
    • many of these do not require programming!