Spatial Layout

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CS 294-10: Visualization
Spring 2011

Announcements

Final project

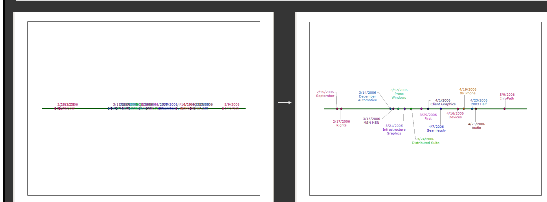
Design new visualization method
- Pose problem, Implement creative solution

Deliverables
- Implementation of solution
- 8-12 page paper in format of conference paper submission
- 2 design discussion presentations

Schedule
- Project proposal: 3/14
- Project presentation: 4/4
- Final paper and presentation: TBD

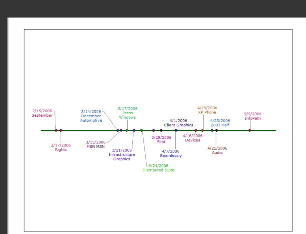
Grading
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

Example: Timeline label layout



Problem

Input: Set of graphic elements (scene description)
Goal: Select visual attributes for elements
- **Position**
- Orientation
- Size
- Color
- …

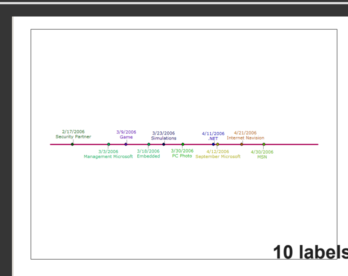


Topics

Direct rule-based methods
Constraint satisfaction
Optimization
Example-based methods

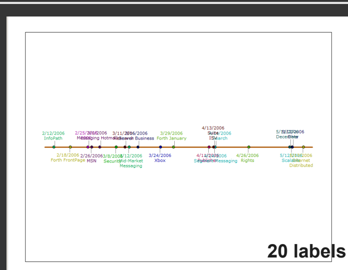
Direct Rule-Based Methods

Rule-based timeline labeling



- Alternate above/below line
- Center labels with respect to point on line

Rule-based timeline labeling



- Alternate above/below line
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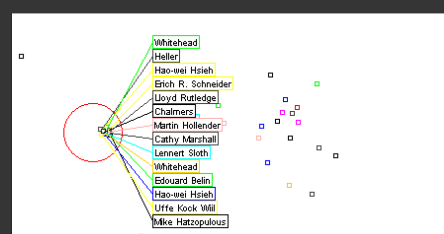
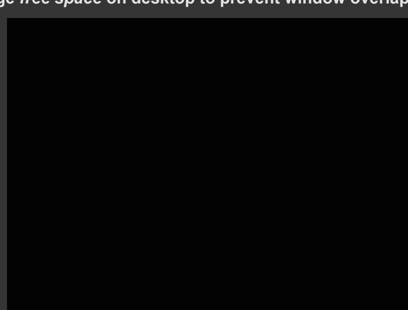
Excentric labeling [Fekete & Plaisant 99]



http://www.cs.umd.edu/hcil/excentric/

Dynamic space management [Bell 00]

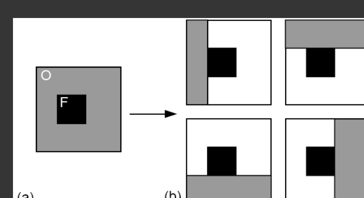
Manage *free space* on desktop to prevent window overlap



Dynamic space management [Bell 00]

Goal: Place new elements to avoid overlap

- Elements are axis-aligned rectangles
- Keep track of largest empty space rectangles



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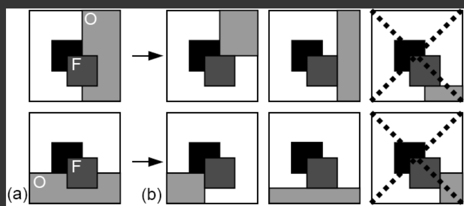


Pros and cons

Pros

- **Designed to run extremely quickly**
- **Simple layout algorithms are easy to code**

Cons

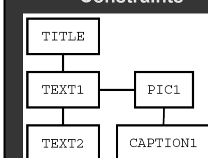
- **Complex layouts require large rule bases with lots of special cases**

Linear Constraint Satisfaction

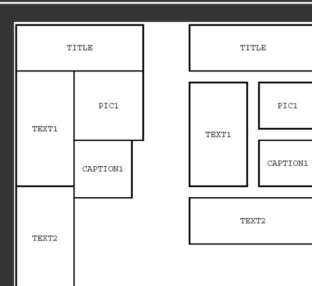
Network of layout constraints

TITLE ABOVE TEXT1
TITLE FULL PAGE WIDTH
TEXT1 LEFT OF PIC1
CAPTION1 BELOW PIC1
TEXT2 BELOW TEXT1

Constraints



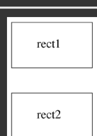
Network



Two possible layouts

[from Lok and Feiner 01]

Constraints as linear equations



C1: rect2.top = rect1.top + rect1.height + 10
C2: rect2.height = rect1.height
C3: rect2.bottom = rect2.top + rect2.height

Local propagation

- Set any variable
- Update other variables to maintain constraints

One-way

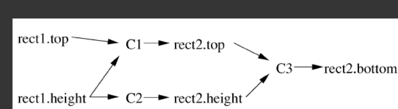
- Each constraint has 1 output variable
- Update output when any input changes

Multi-way

- Each constraint can be written so that any variable is output
- More complicated to maintain

One-way constraints

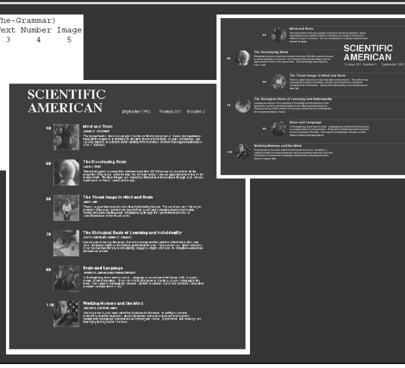
C1: rect2.top = rect1.top + rect1.height + 10
C2: rect2.height = rect1.height
C3: rect2.bottom = rect2.top + rect2.height



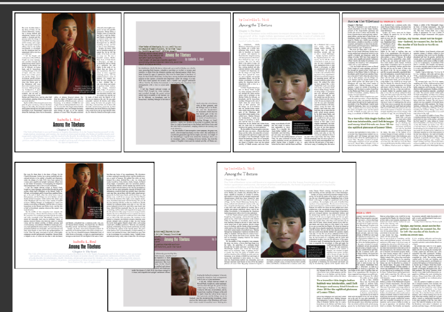
One-way constraints form a directed acyclic graph (DAG). Given the value for any variable we propagate it's value locally through the graph updating the other variable.

Page layout example [Weitzman and Wittenburg 94]

```
(Defrule (Make-Article The-Grammar)
  Article -> Text Text Text Number Image
     0         1    2    3     4      5
  (Author-Of 2 1)
  (Description-Of 4 1)
  (Page-Of 4 1)
  (Image-Of 5 1)
  (article-name 0) = r
  (article-image 0) = 5
  :OUT
  (right-of 1 5)
  (top-aligned 1 5)
  (top-aligned 5 4)
  (spaced-below 2 1)
  (spaced-below 3 2)
)
```

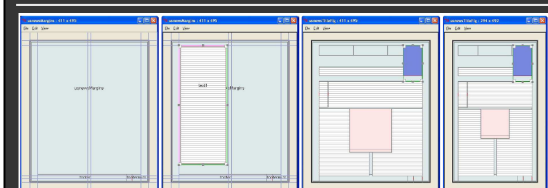


Adaptive document layout [Jacobs 03]



Users authors templates which use one-way constraints to adapt to changes in page size

ADL template authoring [Jacobs 03]



Adaptive Grid~Based Document Layout

Chuck Jacobs[1] Wilmot Li[2] Evan Schrier[2]
David Bargeron[1] David Salesin[1,2]

[1]Microsoft Research [2]University of Washington

Pros and cons

Pros

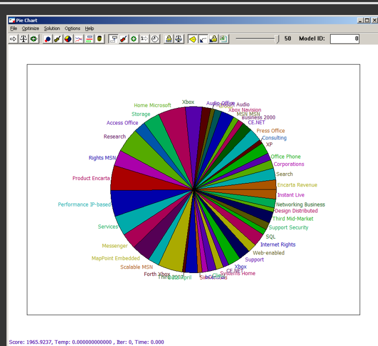
- Often run fast (at least one-way constraints)
- Constraint solving systems are available online
- Can be easier to specify relative layout constraints than to code direct layout algorithm

Cons

- Easy to over-constrain the problem
- Constraint solving systems can only solve some types of layout problems
- Difficult to encode desired layout in terms of mathematical constraints

Optimization

Demo



Layout as optimization

Scene description

- **Geometry:** polygons, bounding boxes, lines, points, etc.
- **Layout parameters:** position, orientation, scale, color, etc.

Large design space of possible layouts

To use optimization we will specify …

- **Initialize/Perturb functions:** Form a layout
- **Penalty function:** Evaluate quality of layout
- **.. and find layout that minimizes penalty**

Optimization algorithms

There are lots of them:

line search, Newton's method, A*, tabu, gradient descent, conjugate gradient, linear programming, quadratic programming, simulated annealing, …

Differences

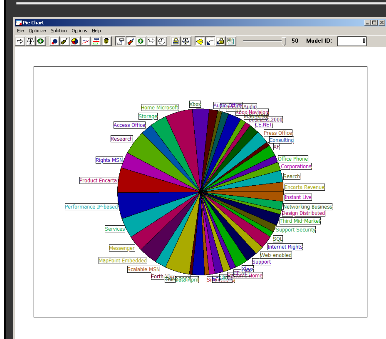
- Speed
- Memory
- Properties of the solution
- Requirements

Simulated annealing

currL ← Initialize() — Form initial layout
while(**! termination condition)**
  newL ← Perturb(***currL***) — Perturb to form new layout
  currE ← Penalty(***currL***) — Evaluate quality of layouts
  newE ← Penalty(***newL***)
  if((***newE*** **<** ***currE***) **or** — Always accept lower penalty
    (rand[0,1) < $e^{-\Delta E/T}$**))** — Small probability of accepting higher penalty
    then ***currL*** ← ***newL***
  Decrease(*T*)

Perturb: Efficiently cover layout design space
Penalty: Describes desirable/undesirable layout features

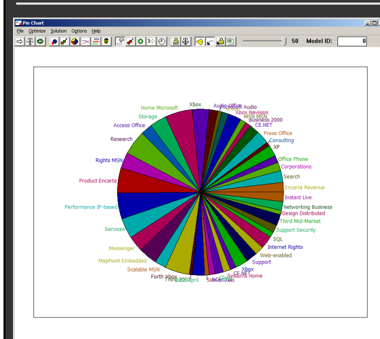
Scene description



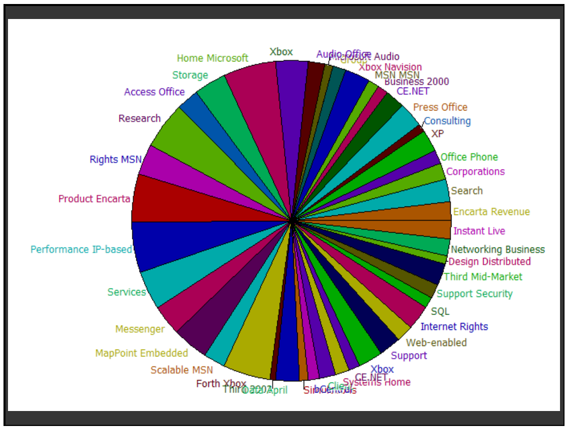
Geometry

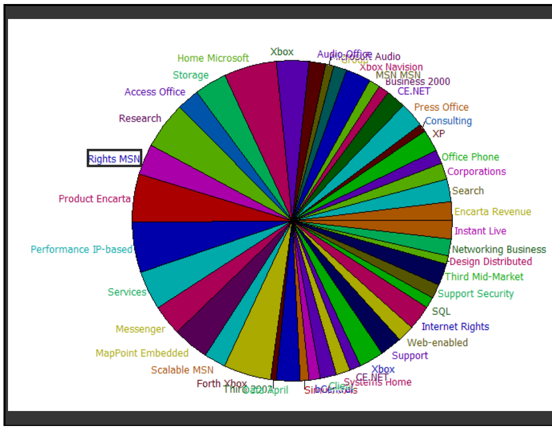
- **Pie slices**
  anchors for labels
- **Labels**
  bounding boxes

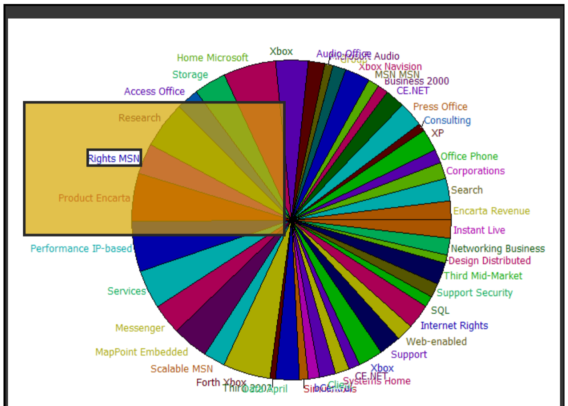
Layout parameters

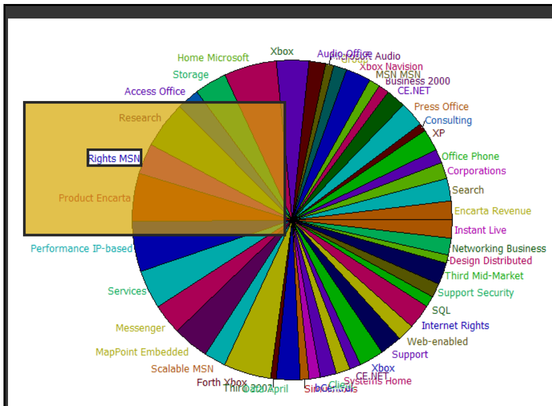


- **Position *(x, y)***
- **Leader line**
- **Word wrap**
- Color
- Alignment
- Orientation
- Scale

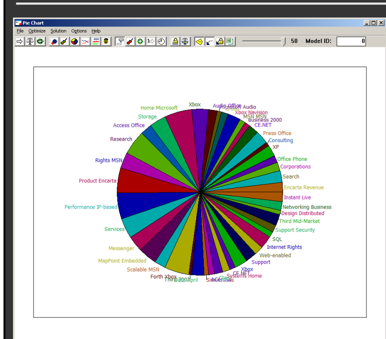








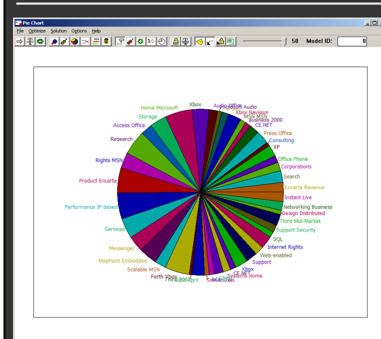
Many dimensions → large space



- **Position *(x, y)***
- Leader line
- Word wrap
- Color
- Alignment
- Orientation
- Scale

2D x 50 labels → 100D space

Penalties



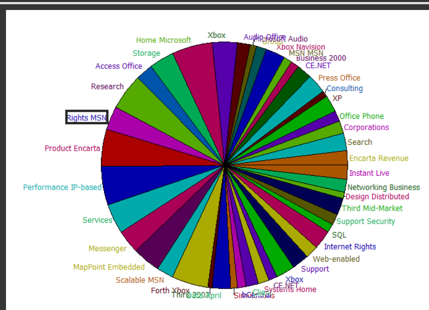
Overlap & Distance
- Label – anchor slice
- Label – other slices
- Label – label

Leader lines
- Length
- Intersections

Word Wrap

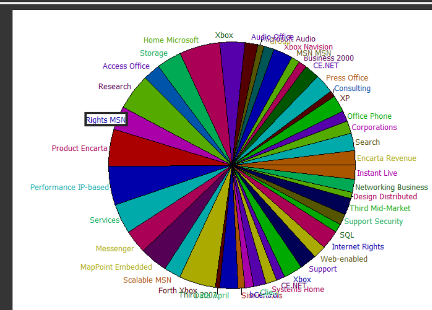
Annealing minimizes sum of all penalties

Overlap: Label – Anchor Slice



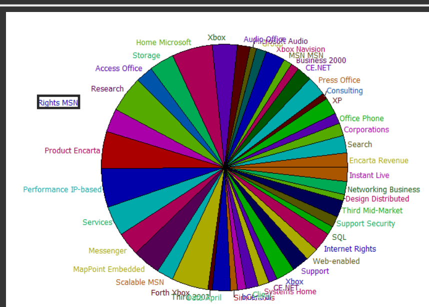
Avoid partial overlap: No penalty if fully inside /outside

Overlap: Label – Anchor Slice



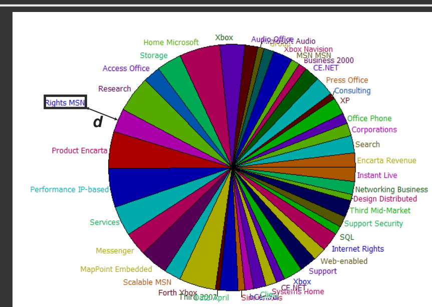
Penalize partial overlap by overlap amount

Distance: Label – Anchor Slice



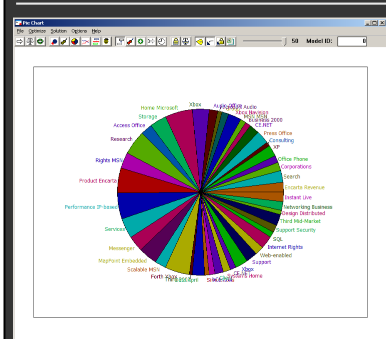
Ensure label near center of edge of anchor slice

Distance: Label – Anchor Slice



Minimize distance *d*

Penalties



Overlap & Distance

- Label – anchor slice
- Label – other slices
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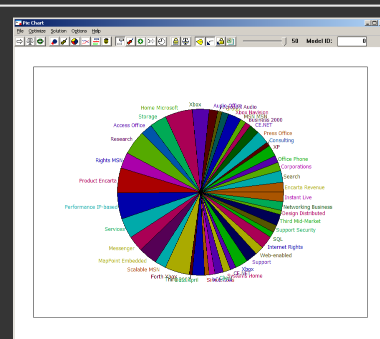
Leader lines

- Length
- Intersections

Word Wrap

Annealing minimizes sum of all penalties

Demo



Pros and cons

Pros

- Much more flexible than linear constraint solving systems

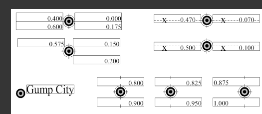
Cons

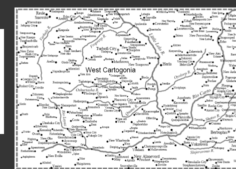
- Can be relatively slow to converge
- Need to set penalty function parameters (weights)
- Difficult to encode desired layout in terms of mathematical penalty functions

Design principles

Sometimes specified in design books

- Tufte, Few, photography manuals, cartography books …
- Often specified at a high level
- Challenge is to transform principles into constraints or penalties





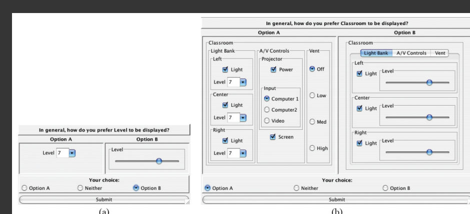
Cartographer Eduard Imhof's labeling heurists transformed into penalty functions for an optimization based point labeling system [Edmondson 97]

Example-Based Methods

Preference elicitation [Gajos and Weld 05]

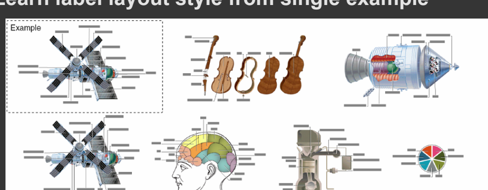
Learn characteristics of good designs

- Generate designs based on a parameterized design space
- Ask designers if they are good or bad
- Learn good parameters values based on responses



Nonlinear Inverse Opt. [Vollick et al. 07]

Learn label layout style from single example



Horizontal/Vertical

Nonlinear Inverse Opt. [Vollick et al. 07]

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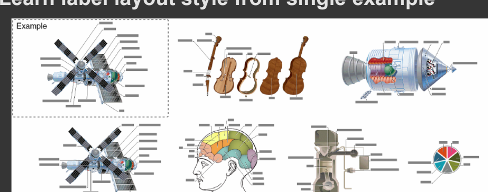


Parallel Leader Lines

Artistic Resizing

A Technique for Rich Scale-Sensitive Vector Graphics

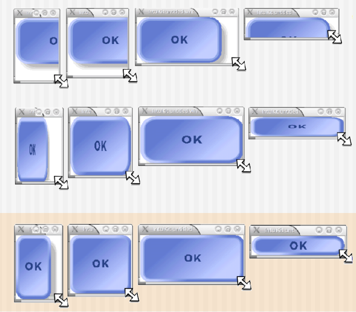
Pierre Dragicevic
Stéphane Chatty
David Thevenin
Jean-Luc Vinot

intuilab

Direction Générale de l'Aviation Civile dgac

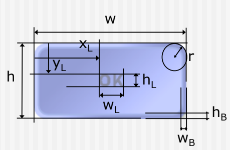
The Resizing Problem

- Fixed size
- Naive scaling
- Artistic resizing



Expressing Artistic Resizing

- Commonly described using formulae



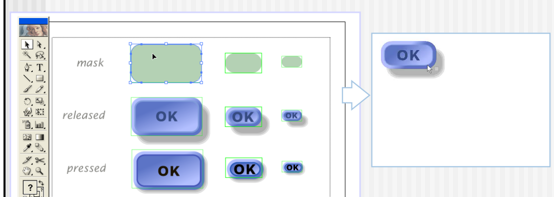
- $x_L = (w-w_L) / 2$
- $y_L = (h-h_L) / 2$
- $w_L = 20$
- $h_L = 10$
- $w_B = 5$
- $h_B = 5$
- $r = 20$

- These formulae are:
  - Translated into code by the programmer
  - Or used as an input to constraint-solving systems

Example-Based Approach

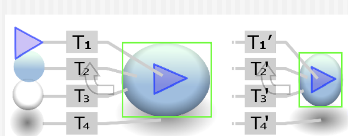
1. Designers produce variants using their authoring tool

2. System interprets the example set



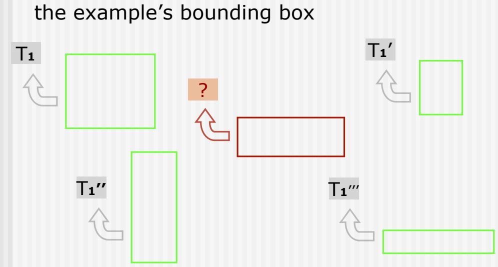
Artistic Resizing
How does it work?

- Assumes the exclusive use of:
  - Copy & paste for adding new examples
  - Affine transformation tools (move, scale, rotate, shear)
- Based on local interpolation of transformations



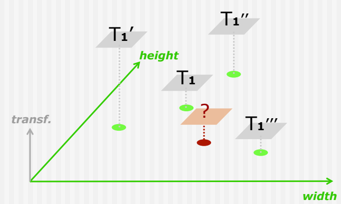
Artistic Resizing
How does it work?

- Each variant of T1 is associated with the example's bounding box



Artistic Resizing
How does it work?

- Problem of multivariate interpolation



Pros and cons

Pros

- Often much easier to specify desired layout via example

Cons

- Usually requires underlying model
- Model will constrain types of layouts possible
- Large design spaces likely to require lots of examples to learn parameters well