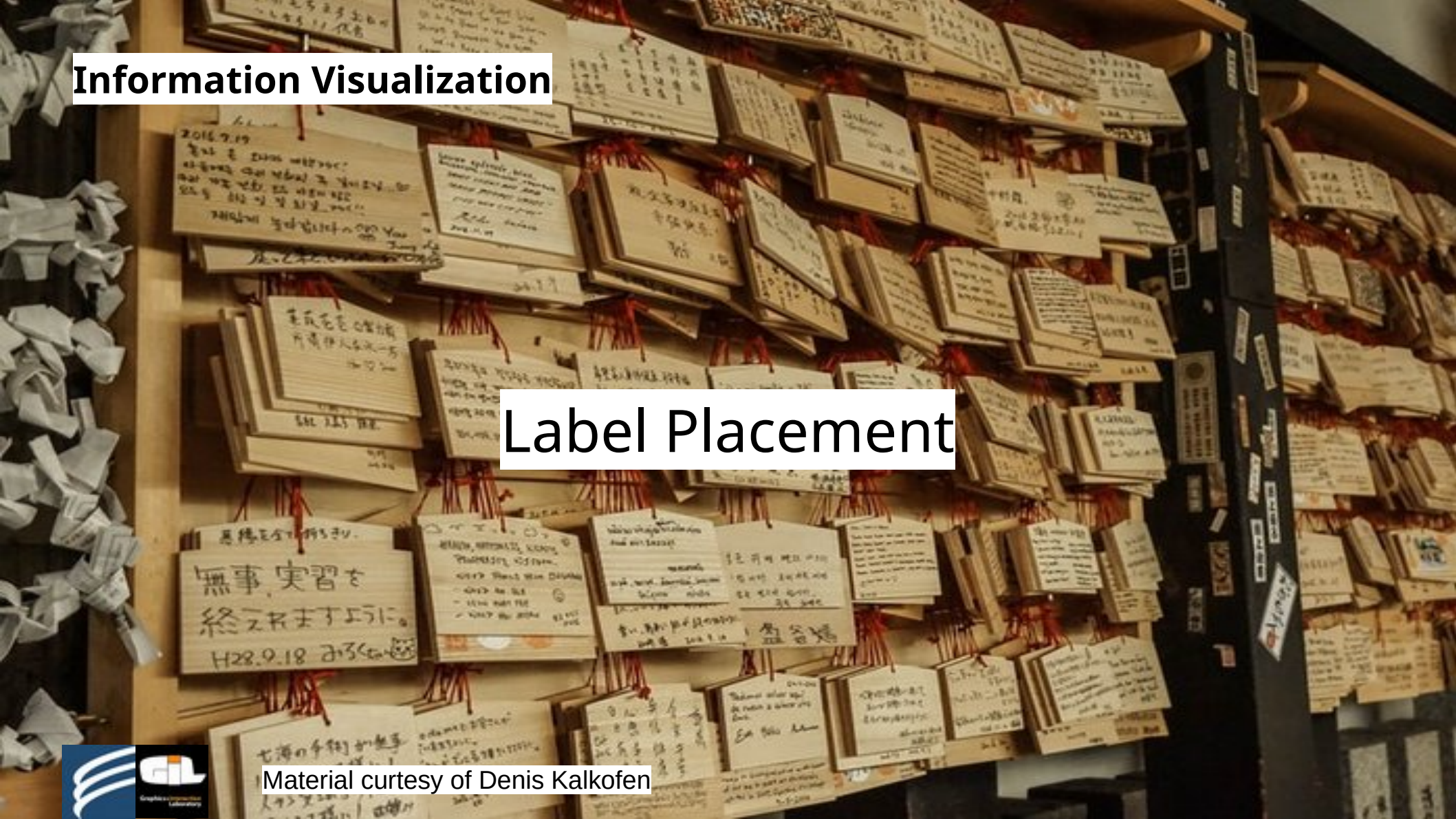
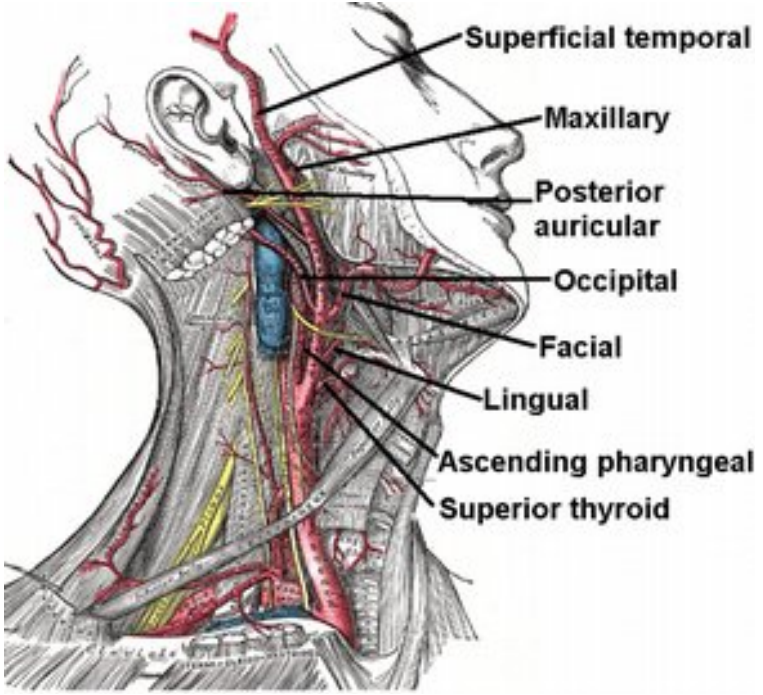
Information Visualization



Label Placement

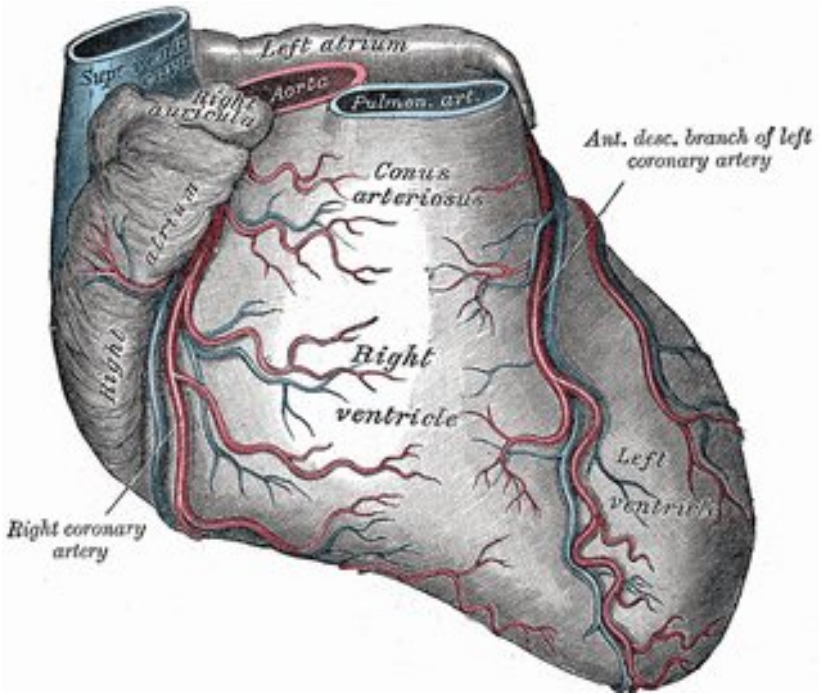
Material curtesy of Denis Kalkofen

Illustrative Rendering

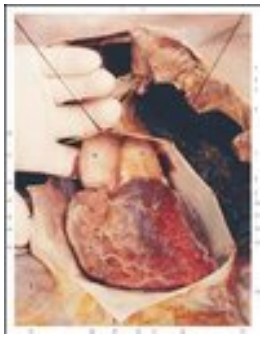


Henry Gray (1918). Anatomy of the Human Body.

Illustrative Rendering

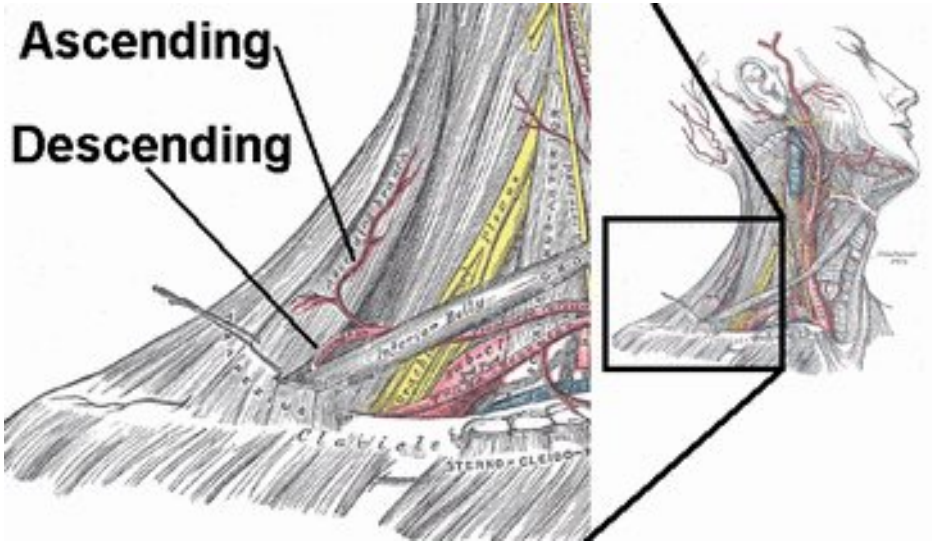


- Meant for communication
- Anatomy, Assembly, …
- Trade realism for communication



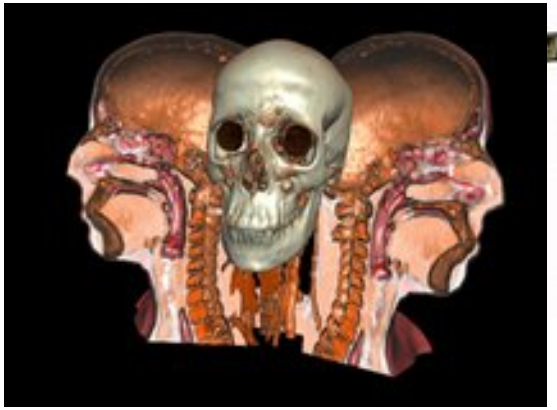
Henry Gray (1918). Anatomy of the Human Body.

Topics



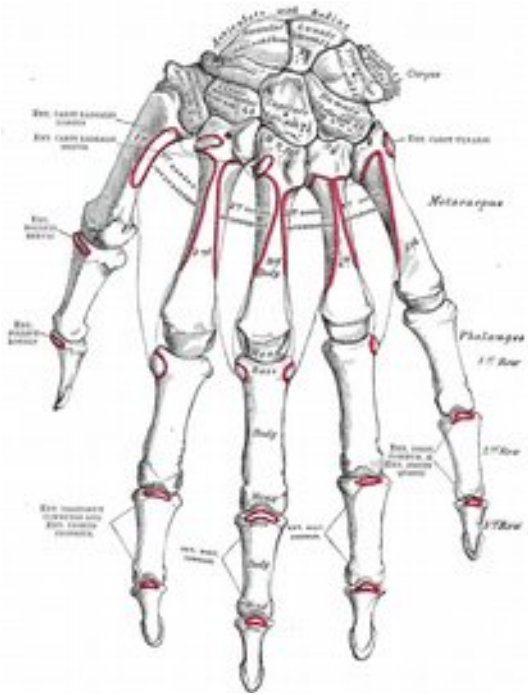
Henry Gray (1918). Anatomy of the Human Body.

Illustrative Rendering

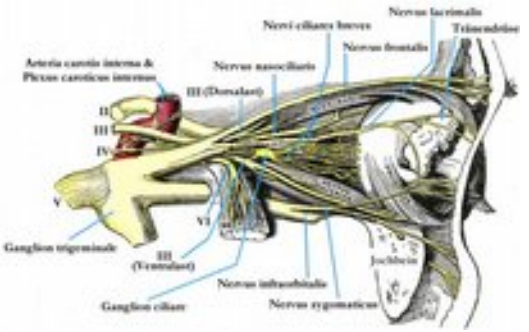


- High level techniques
- X-Ray Vision (present hidden structure while indicating occluding elements)

Illustrative Rendering



- High level techniques
  - Label Placement



Map Labeling

- Text → name of map feature
- Features → points, lines, areas

Point Features

- Places on a small-scale map
- Cities, Sights, …

Point Features

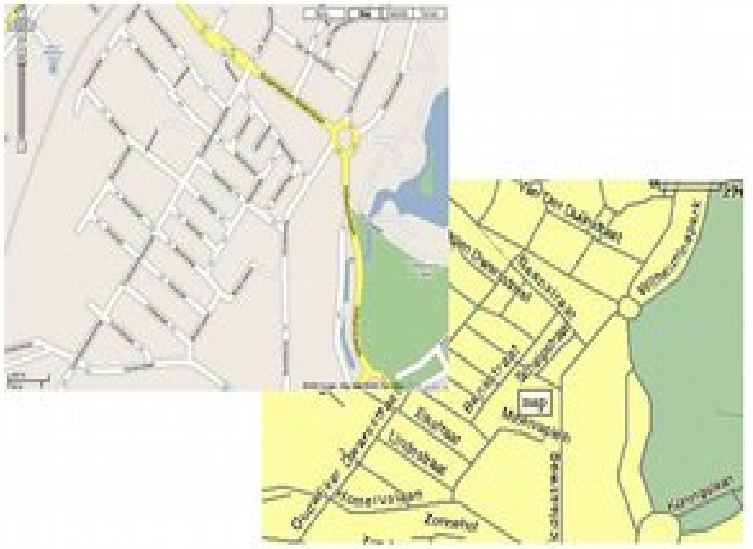
Map of Environmental Radioactivity Level (μSv/hr) before and after March 11, 2011.

- Places on a small-scale map
- Cities, Sights, …
- Measured values at measurement points
- Heights of peaks, Radioactivity, …

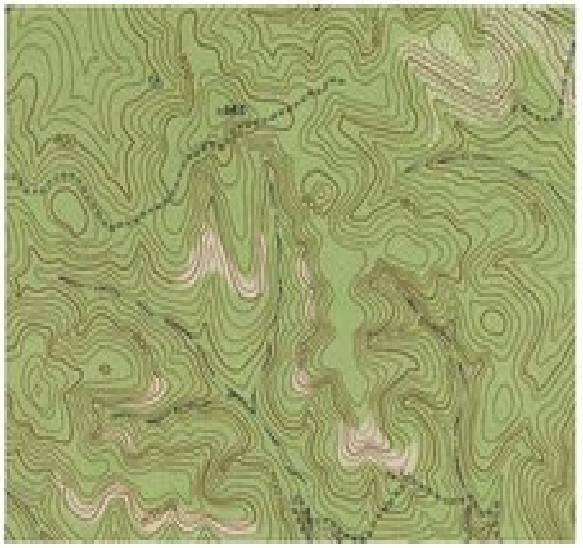
Labels of line features

- Rivers
- Heights on contour lines
- Streets

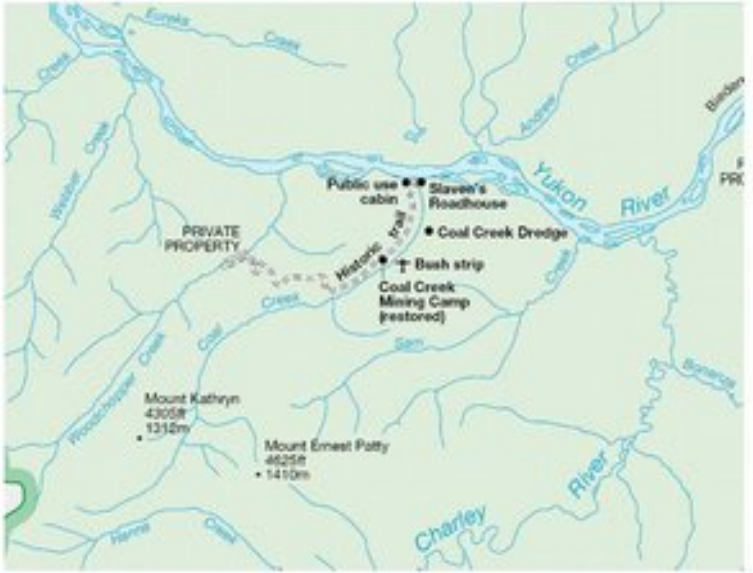
Labels of line features



Labels of line features



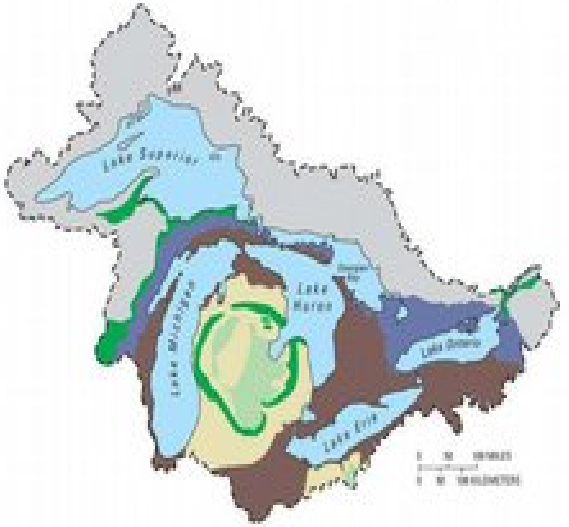
Labels of line features



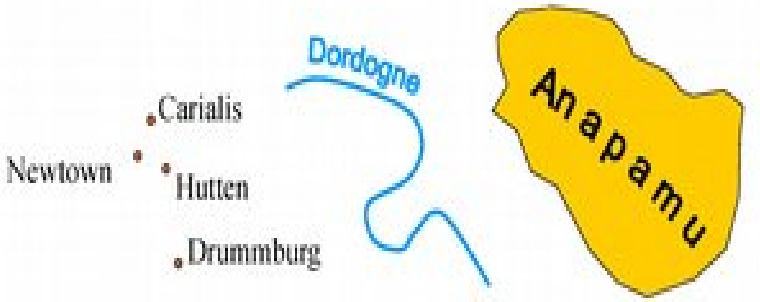
Labels of areal features

- Countries, oceans, forests, lakes

Labels of areal features



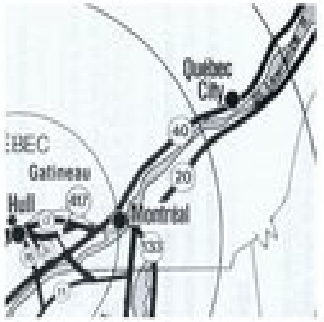
Three kinds of labels



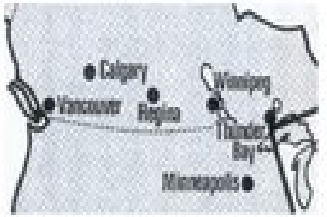
Label placement

- Where should the text be placed? Which shape?
- 20% - 50% of the manual map production time; can be automated
- Which rules do cartographers use?
  - No overlap → readability
  - Clear for which feature → association
  - Aesthetical guidelines

Problematic cases



Problem visibility highway 20



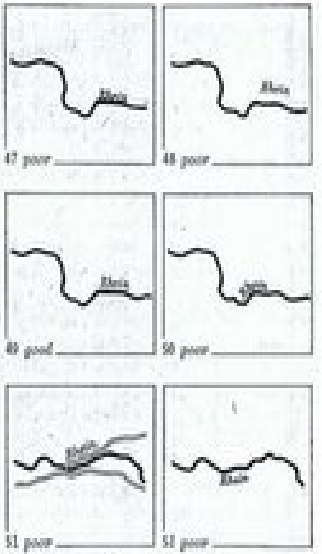
Problem association Thunder Bay and point

Problem readability name

Rules according to Imhof

Eduard Imhof (1895-1986)

- Swiss Cartographer
- "Positioning Names on Maps" (1962/1975)



Example

Specific rules point labels

- Label must be close to point, preferably to right and above
- Labels are placed horizontal, no extra spacing
- No overlap with other labels, except perhaps in the spacing of the areal label
- Label may intersect line feature; then line must be interrupted
- Points at a large body of water must have their label in the water. In other cases there may be no line between a point and its label
- If it cannot be avoided, a name may be split over two lines of text

Specific rules line labels

- Label must follow shape of river
- Label should not bend upwards and downwards consecutively
- At long line features the label must be repeated
- No or little extra spacing between characters, spacing between words of the label is allowed
- For vertical line features: upward reading direction left on the map and downward right on the map
- Contour lines: labels must interrupt contour line; top of label points to higher regions

Specific rules areal labels

- Horizontal labeling is good unless this conflicts with the dominant shape of the region
- Non-horizontal labels must be curved
- Monotonous curving; no inflection points
- Label should be spread over whole region
- Adjacent regions preferably have same shape of label (both horizontal, e.g.)
- Sometimes an areal label may be outside its region, but not in another labeled region
- Small areal features treated as point features

Strategies for automatic label placement

- Compute for each feature various *candidate positions* according to the rules
- Choose for each feature one candidate position, such that the chosen positions do not overlap

- Sometimes a feature cannot be labeled, and sometimes the label of a feature must be repeated

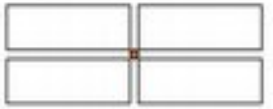
Discrete

Continous

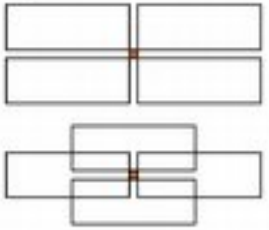
Candidate positions points

- Point labels

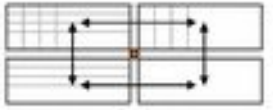
4-position model



8-position model



slider model



More general model → more labels can be placed, but more complex/ expensive to compute

Candidate positions points

- Priority of point label positions

Exhaustive Search

- Perform Backtracking
  - Use pre-defined order of points
  - Successively place label in unobtrusive candidate position
  - If a point cannot be labeled go back to the most recently labeled point and consider new candidate position
  - Point cannot be labeled if no positions without conflict is available or all positions have been tried

SLOW→impractical for large amounts of point labels

Greedy Placement

- Avoid backtracking
- Instead of undoing previously computed placements either
- leave point out
- add overlaps
- More practical than exhaustive search
- Non-optimal solution but suitable trade-off

Gradient Descent

1. For each feature, place its label randomly in any of the available candidate positions.
2. Repeat until no further improvement is possible:
   (a) For each feature, consider moving the label to each of the alternative positions.
   (b) For each such repositioning, calculate the change in the objective function that would result if the label were moved.
   (c) Implement the single label repositioning that results in the most improvement. (Ties are resolved randomly.)

- Random initialization
  - Each iteration chooses best improvement

Gradient Descent

1. For each feature, place its label randomly in any of the available candidate positions.
2. Repeat until no further improvement is possible:
   (a) For each feature, consider moving the label to each of the alternative positions.
   (b) For each such repositioning, calculate the change in the objective function that would result if the label were moved.
   (c) Implement the single label repositioning that results in the most improvement. (Ties are resolved randomly.)

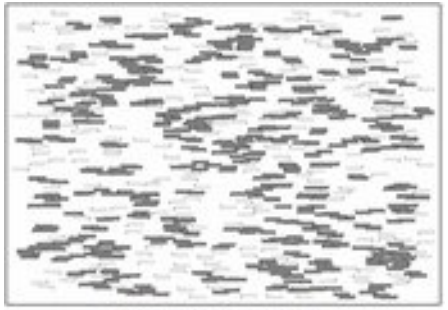
- Problem: local search → will get stuck in a local maximum

Simulated Annealing

1. For each point feature, place its label randomly in any of the available potential positions.
2. Repeat until the rate of improvement falls below a given threshold:
   (a) Decrease the temperature, T, according to the annealing schedule.
   (b) Pick a label and move it to a new position.
   (c) Compute ΔE, the change in the objective function caused by repositioning the label.
   (d) If the new labeling is worse, undo the label repositioning with probability $P = 1.0 - e^{-\Delta E/T}$.

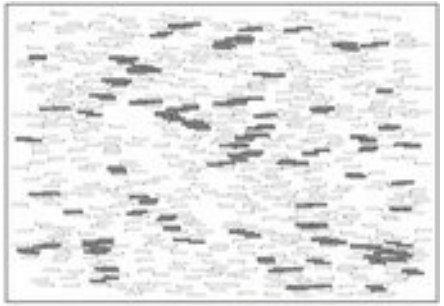
- Approximation of a global optimal solution
- Probability based optimization – accepts also inferior solutions with a probability *p*

Placement strategies

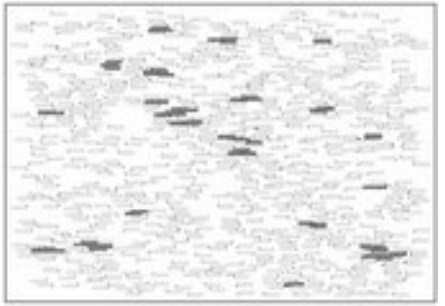


Random Placement (564)

Greedy Depth-First Placement (341)

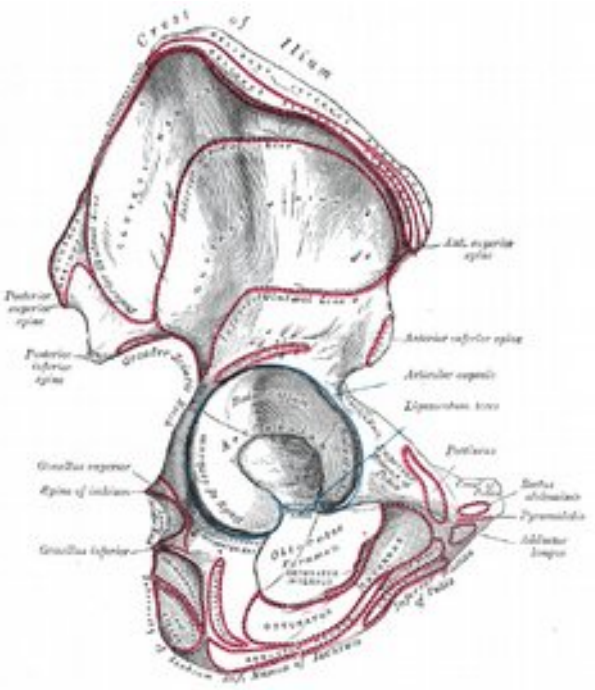


Discrete Gradient Descent (222)



Simulated Annealing (75)

Label Placement for 3d Objects

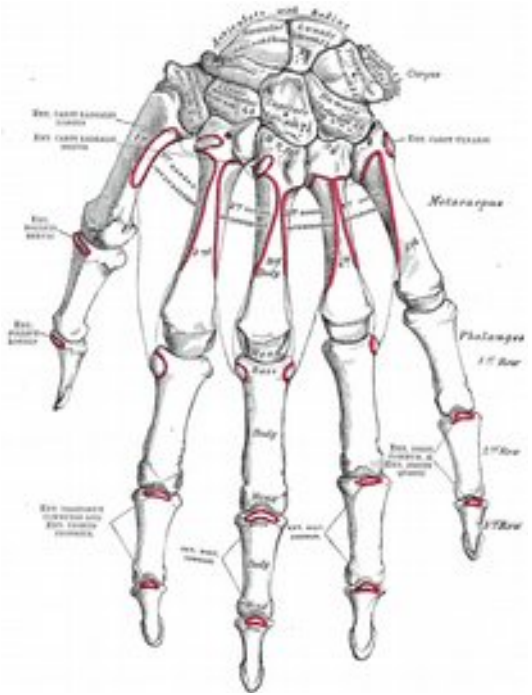


- Area features
- Line features
- Point features

Henry Gray: Anatomy of Human Body
Lea & Febinger, Philadelphia, 20th edition, 1918
http://www.bartley.com

Imagebank British Orthopaedic Association

Label Classification

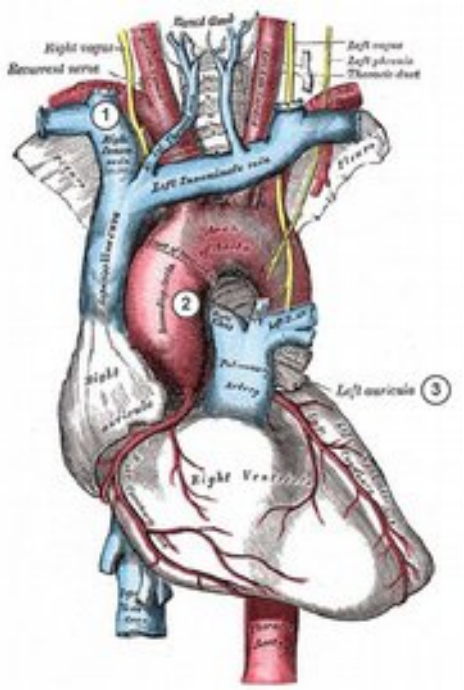


[Gray]

- Internal
- Object aligned
- Straight
- External

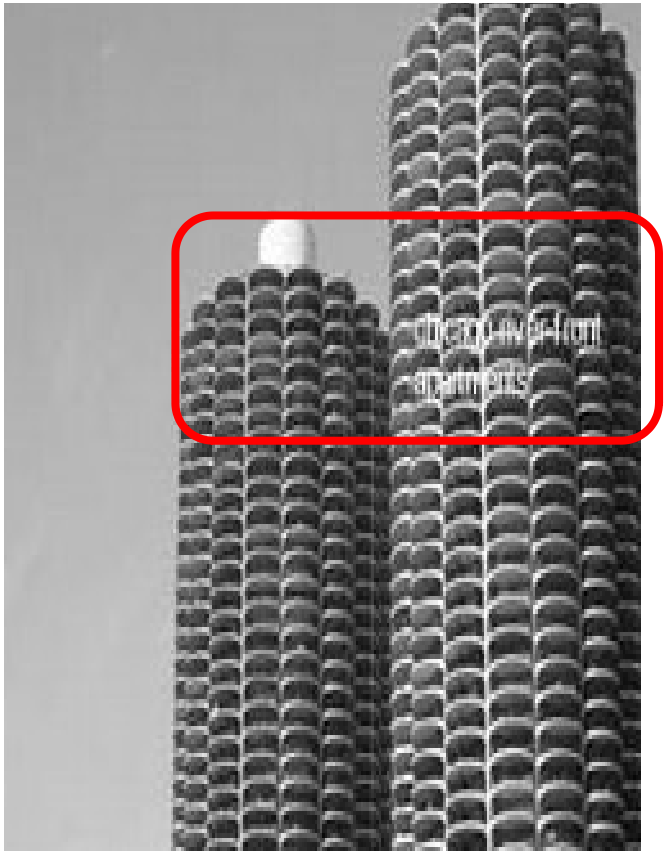
Label Placement for 3d Objects

- Label style: describes the label itself and it’s relation to ’its’ object (single label)
  - Internal (on top of object) or external (besides object)
  - Size(importance)
  - Contrast to background
  - …
- Layout: describes the group sof labels
  - Avoid overlapping of labels & connections
  - Layout strageties:
    - Aesthetic (flushed, radial,…)
    - Functional (functional grouping, importance driven)



[Gray „Anatomie of the Human Body“]

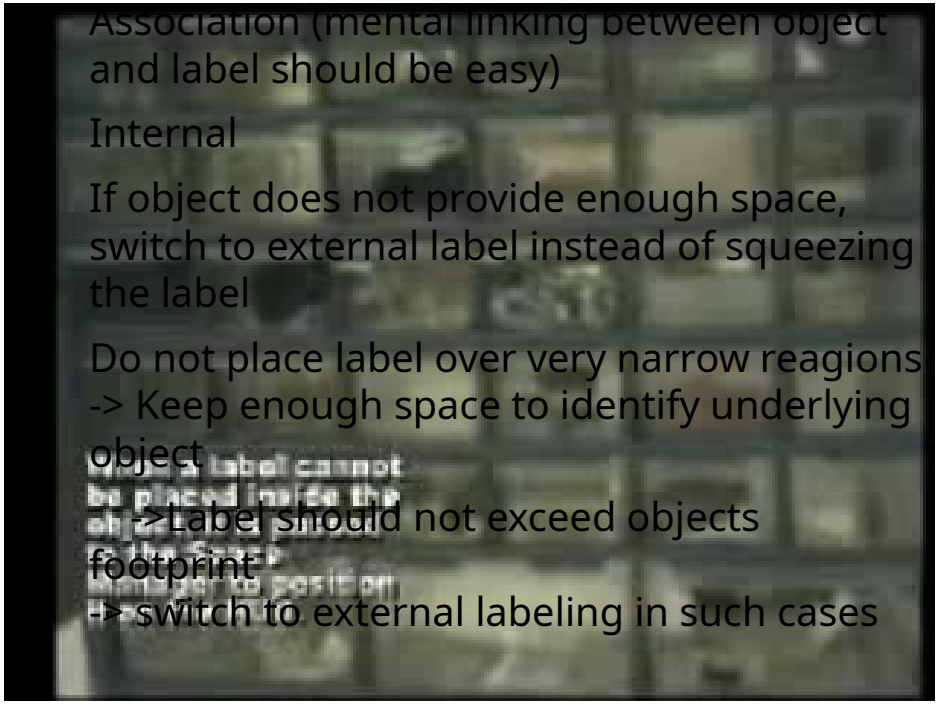
Quality Parameter of Labels



[Leykin04]

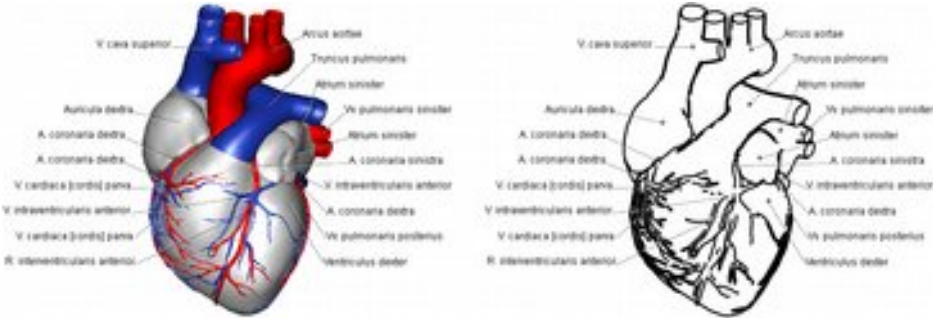
- Readability
  - Internal & External: Background contrast
  - Internal label
- High curvature reduces readabilty, in case of object aligned labels -> switch to horizontal alignment

Quality Parameter of Labels



[Coelho05]

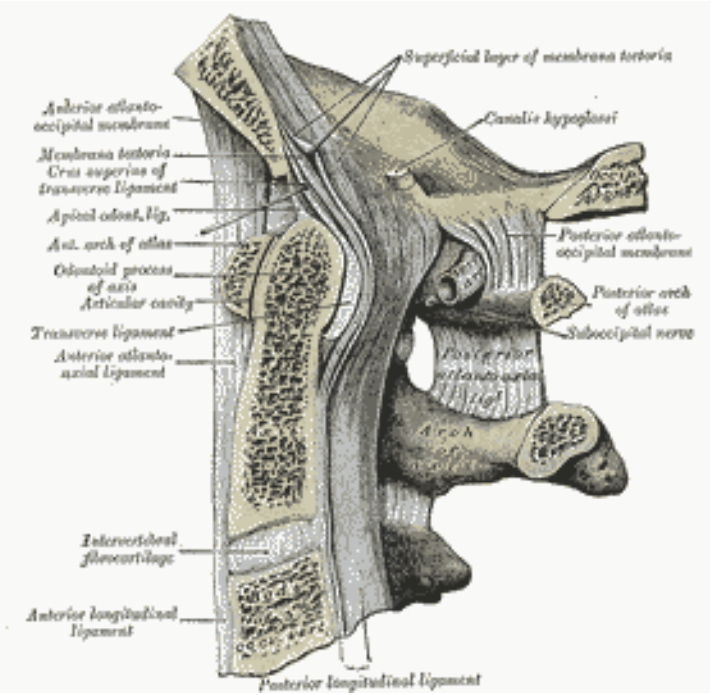
Quality Parameter of Labels



- Association (mental linking between object and label should be easy)
- External
- Labels should not ovelap
- Place label as close as possible to its corresponding object
- Connection lines should not overlap
- Minimize number of bends of connection line
- Anchor points must overlay the corresponding object

Quality Parameter of Labels

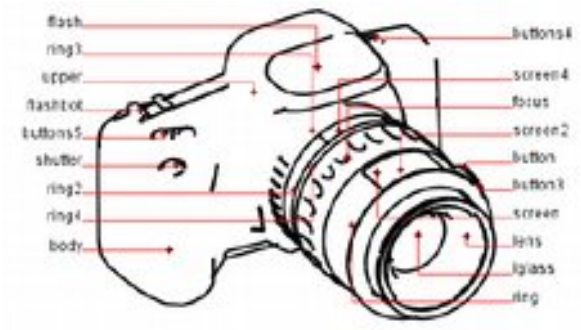
- Aesthetic
- Internal
- Label should be concentric placed over object
- External
- Anchor points should not form cluster

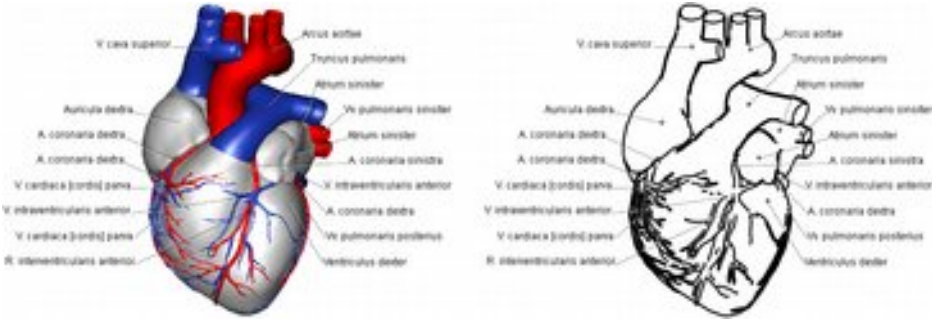


Quality Parameter of Interactive Labels

- Frame-to-Frame Coherency (Distance between the same label in subsequent frames should be minimized)

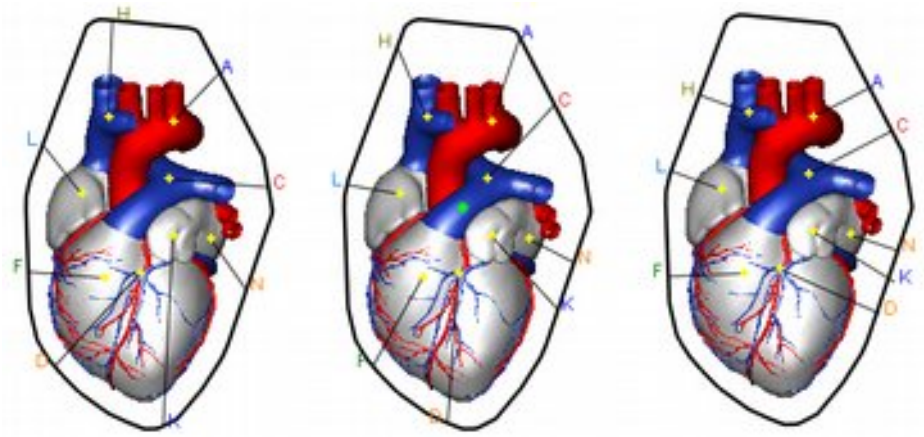
External Labels: Connection Lines





- **Straight** lines
  - Labels and anchor points are connected with straight lines
- **Orthogonal** lines
  - Connecting lines are axis-aligned and the bends are made at orthogonal angles

Layout Classification: Straight lines



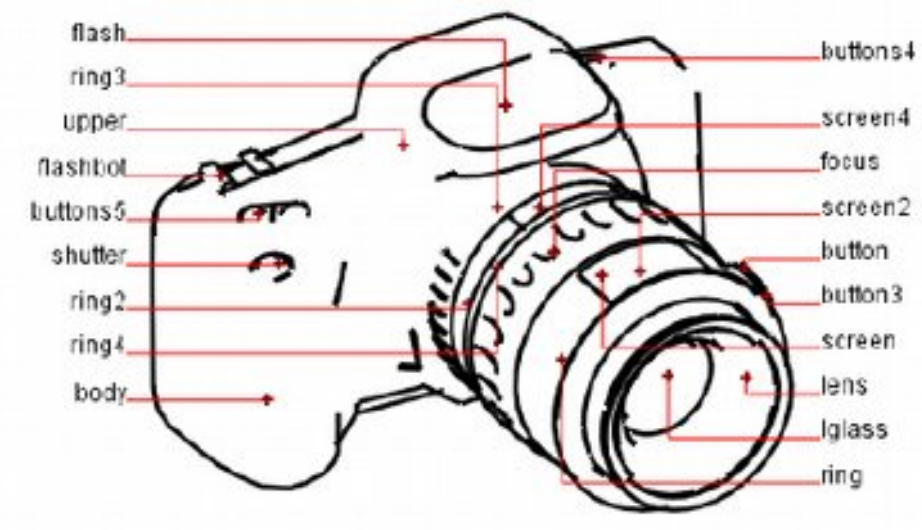
[Ali05]

[Sobotta]

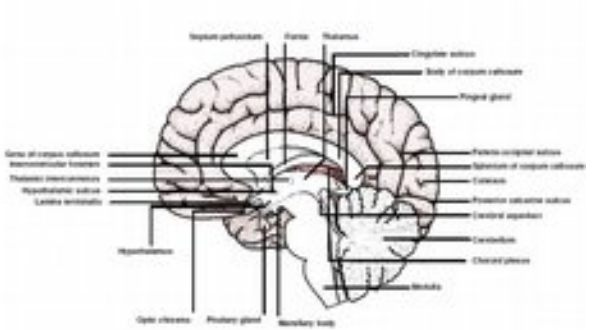
- Silhouette based: Labels are placed near the silhouette
- Ring: placed at regular intervals
- Radial: in radial form with respect to a common origin

Layout Classification: Orthogonal lines

[Hartmann05]



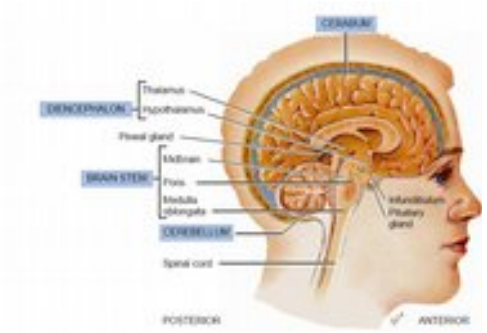
[Rogers]



- often flushed arranged
  - Left/Right aligned
  - Top/Down aligned

Functional Labeling

[Götzelmann06]



[Tortora]

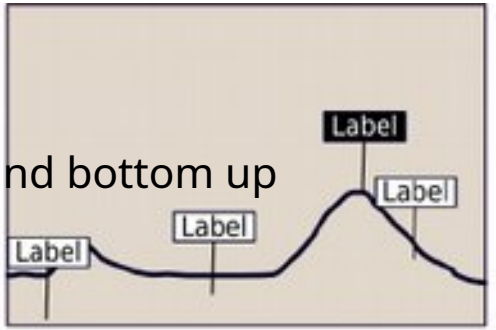
- Use style and layout to communicated additional information next to objects name
- Contextual grouping

Automatic Placements

Image Space View Management of External Labels

Step 1

- sort labels – back to front and bottom up



Schritt 2

- Finde ’gültige Position’ für das aktuelle Label durch eine der beiden View-Management-Strategien
  - Growing Border
  - Interval Slot Management

Growing Border

- Separate screen-spaceto in slots (keep track of height in each slot)
- find min_y // aus allen Slots des aktuellen Lables
  Label_Position = (x, min_y)

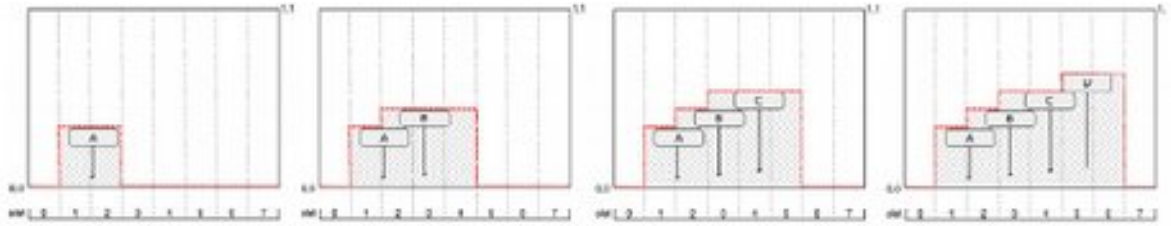
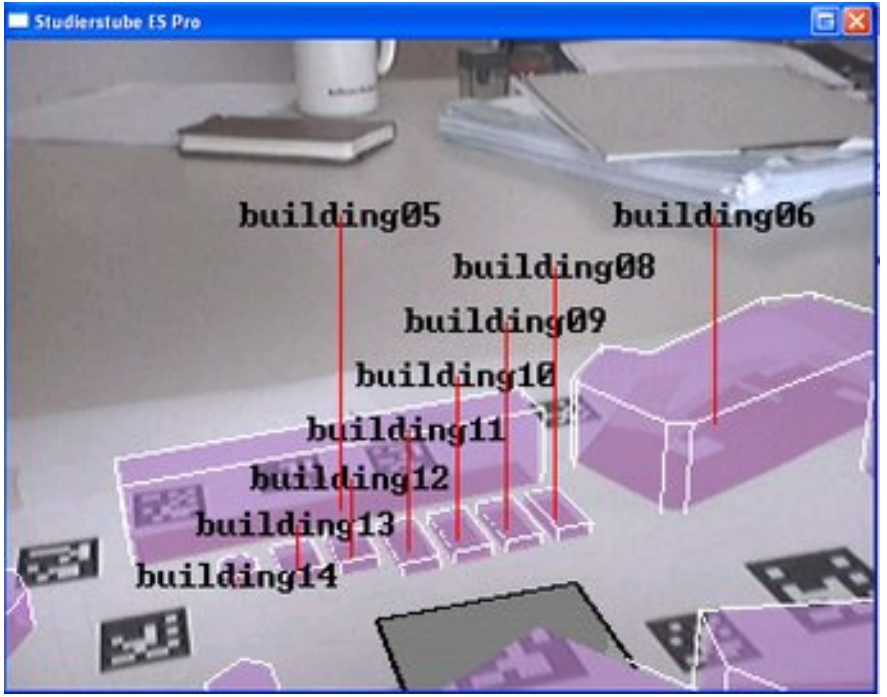


Fig. 4. Placing the labels A-D by the growing-border view management. The occupied view-plane region is hatched.

Growing Border

- Label_Position = (x, min_y)
- Problem → stacks and large areas are unused !



Interval Slot Management

- Durch schrittweises verschieben in Y, finde erste für alle Slots gültige Labelposition
- keep track of height in each slot =>
  NOW: keep track of intervals

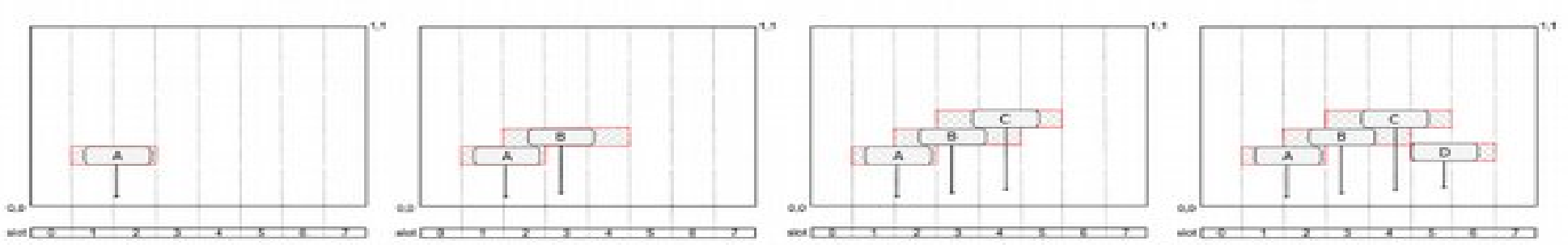
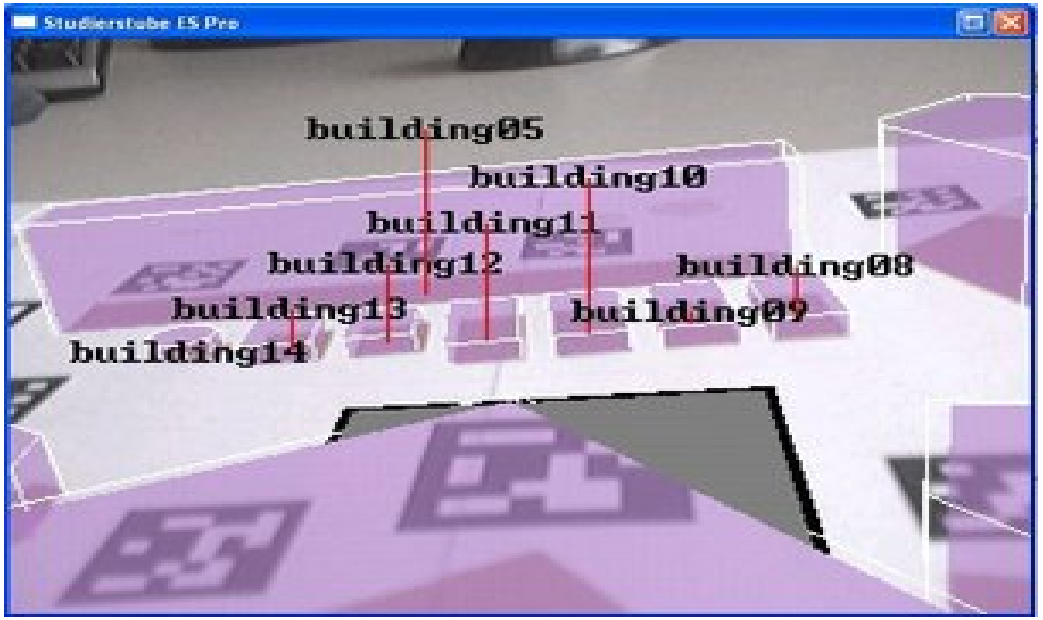


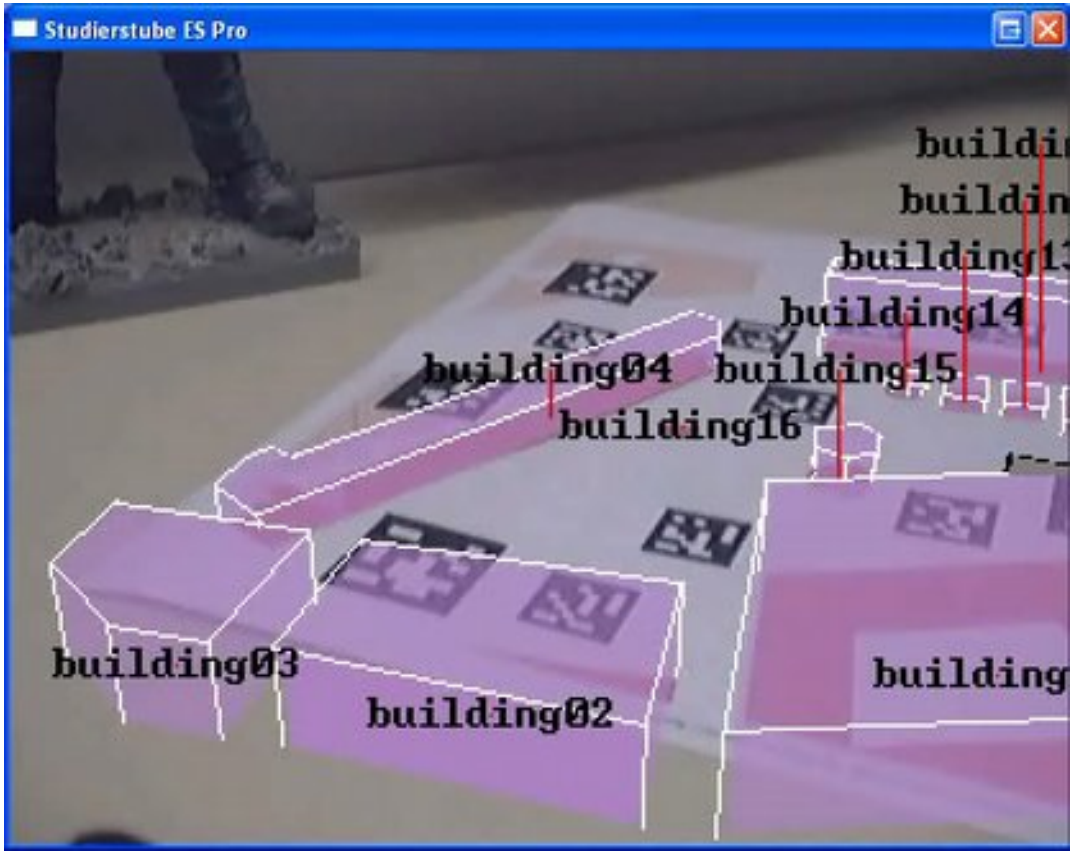
Fig. 5. Placing the labels A-D by the interval-slot view management

Internal Slot Management



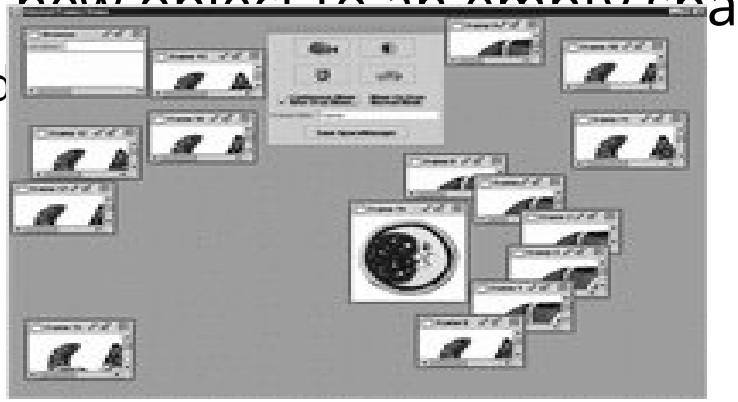
Finde Position durch schrittweise Verschiebung in Y

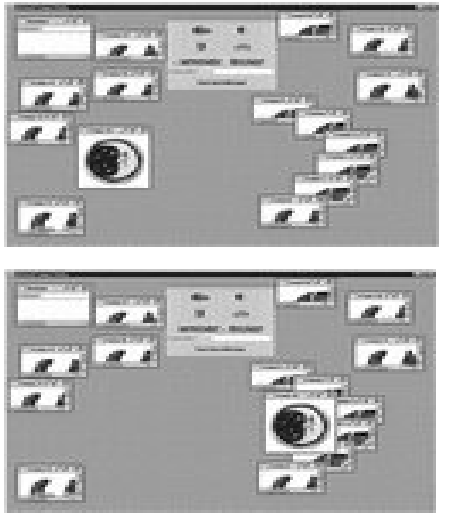
Problems


Studierstube ES Pro
building04
building15
building16
building14
building03
building02

View Management
- Strategies to avoid overlapping -

- B. Bell, “Dynamic Space Management”, 2000
- Manage ‘empty rectangular spaces’
- Incrementally add or remove rectangles
- Prevent overlaps by:
  - (A) Move new object to an empty space
    - Just ac

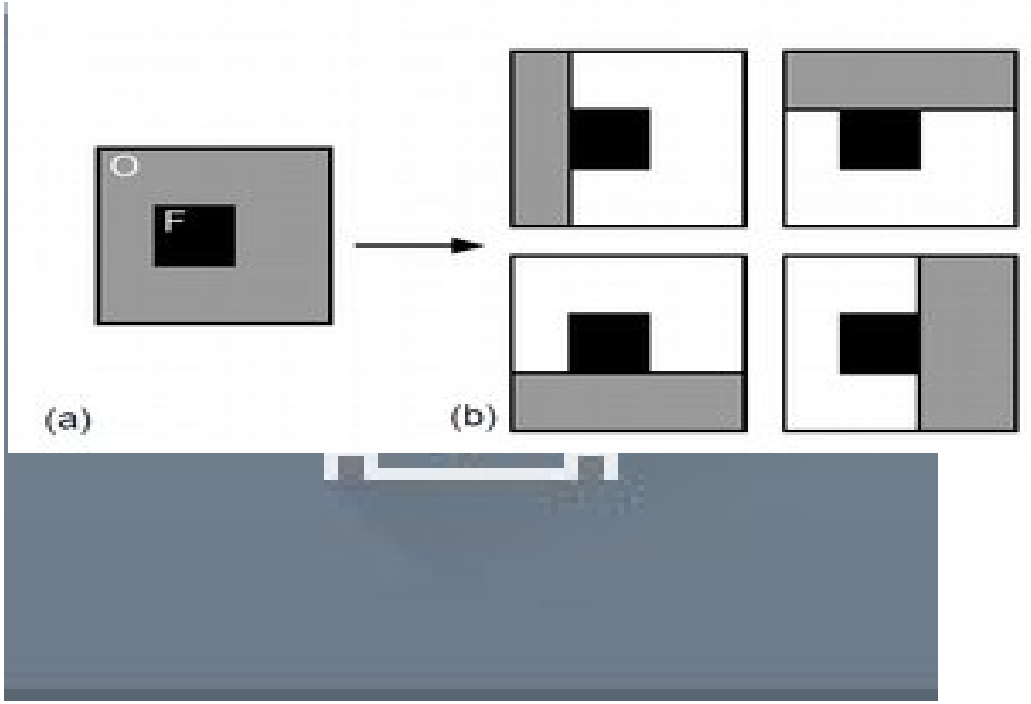




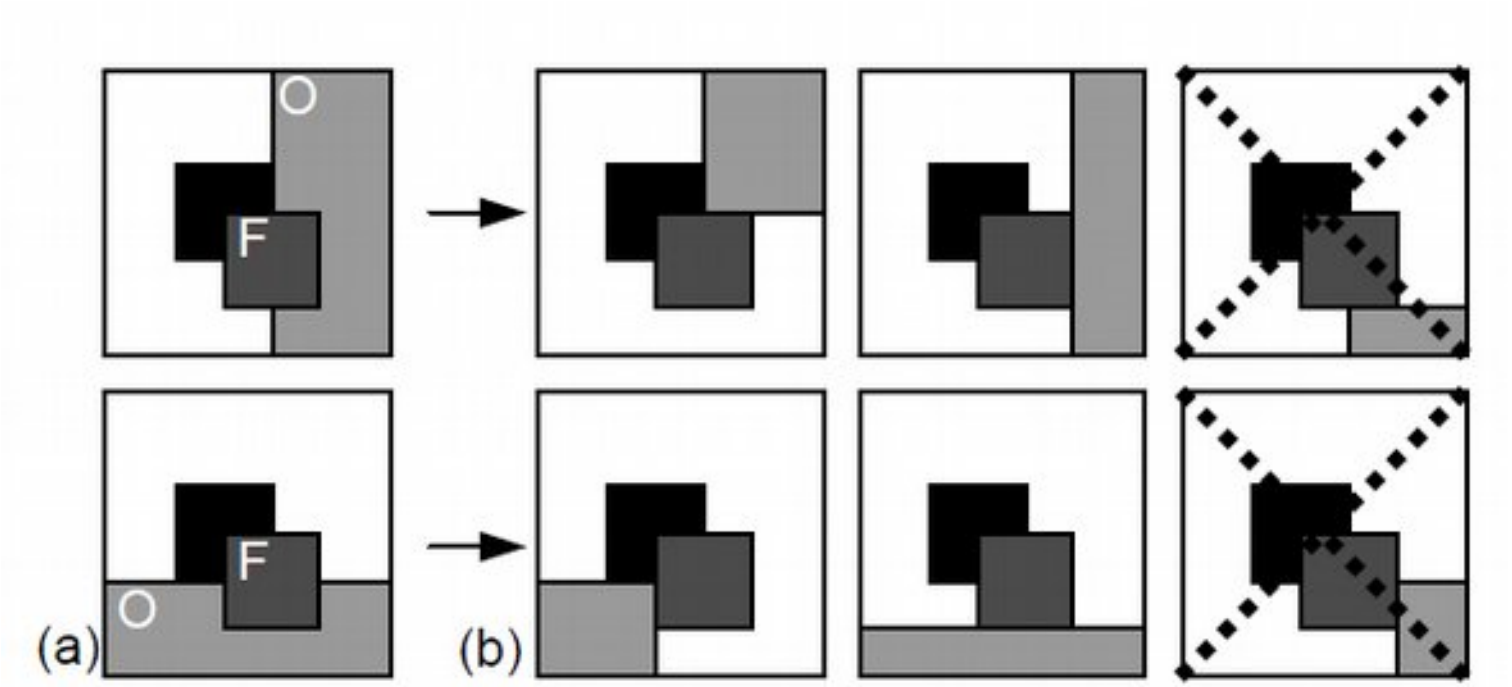
- Augment annotations

Largest Empty-Space Rectangles

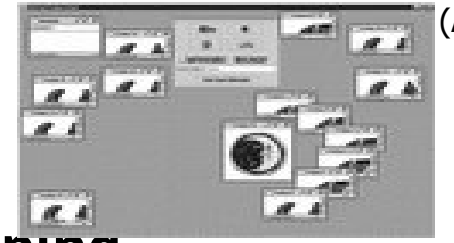
- For each edge eF of F which cuts underlying empty rectangle O
- Create new empty rectangle
- New empty rectangle consists of eF +3edges of O
- Find new rectangles which are fully inside other rectangles -> looking for the largest
- Remove original largest rectangles which intersect F



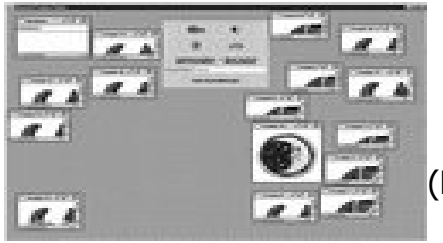
Largest Empty-Space Rectangles



View Management
- Strategies to avoid overlapping -

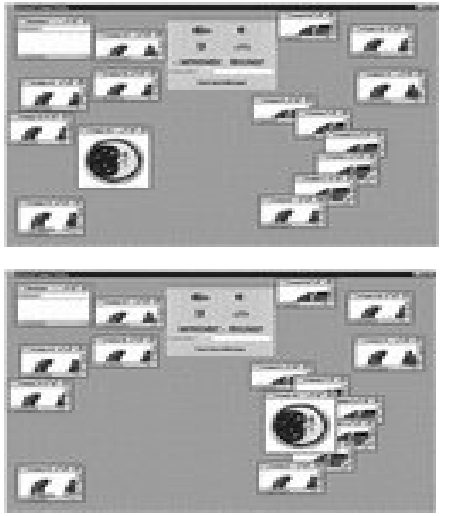


(A)



(B)

- B. Bell, “Dynamic Space Management”, 2000
- Manage ‘empty rectangular spaces’
- Incrementally add or remove rectangles
- Prevent overlaps by:
  - (A) Move new object to an empty space
    - Just add new full-space rectangle
  - (B) Move other objects
    - Delete all intersecting full-space rectangles
    - Add new rectangle
    - Incrementally re-add the deleted rectangles



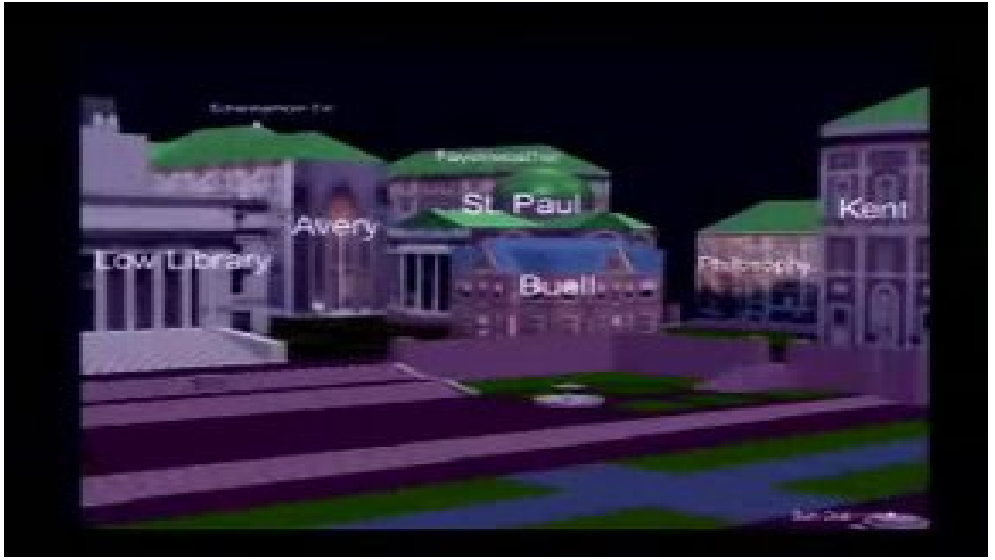
Dynamic Space Management
- Strategies to avoid overlapping -

- Video

View Management
- External Labels -

- “Dynamic Space Management” can be used to prevent overlapping of external labels

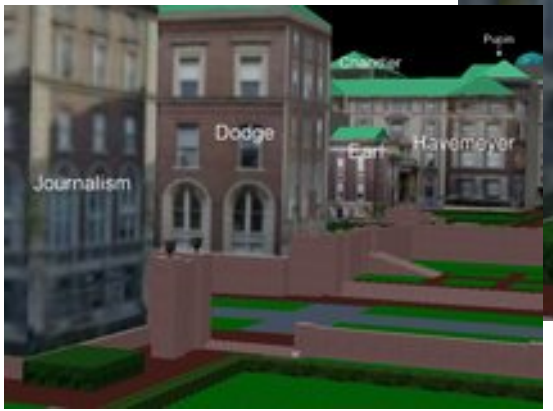
- Augmenting Annotations



View Management
- Internal Labels -

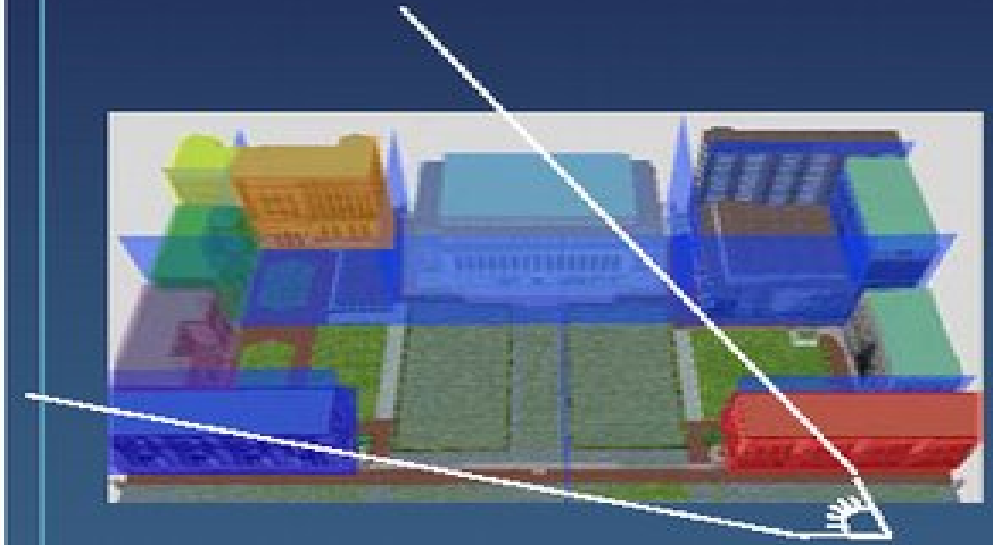
- Avoid overlap of inte
  - Label only if pears there (middle)
  - Move label le (right)

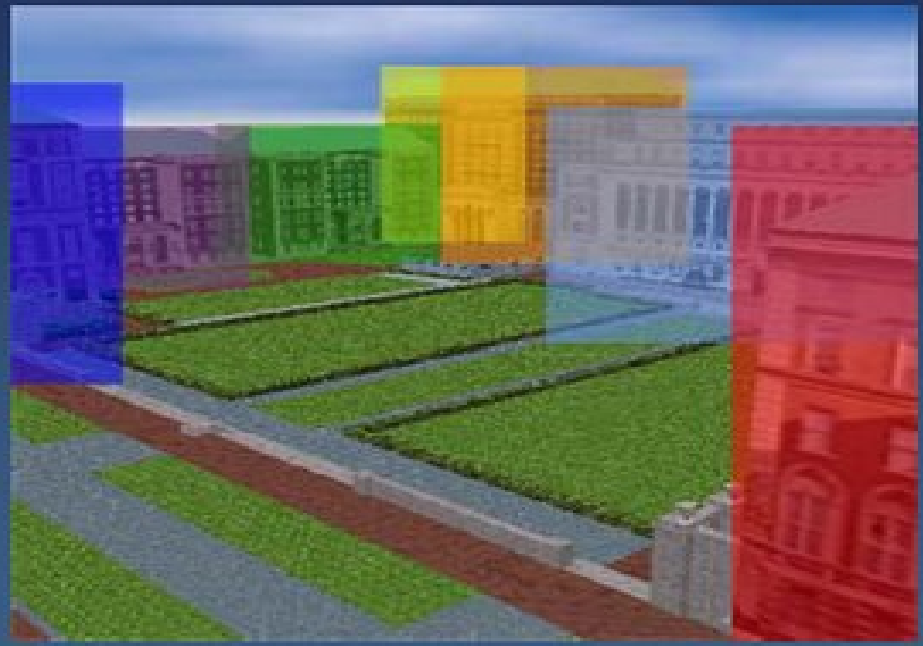
Augmenting Annotations



Annotation Algorithm

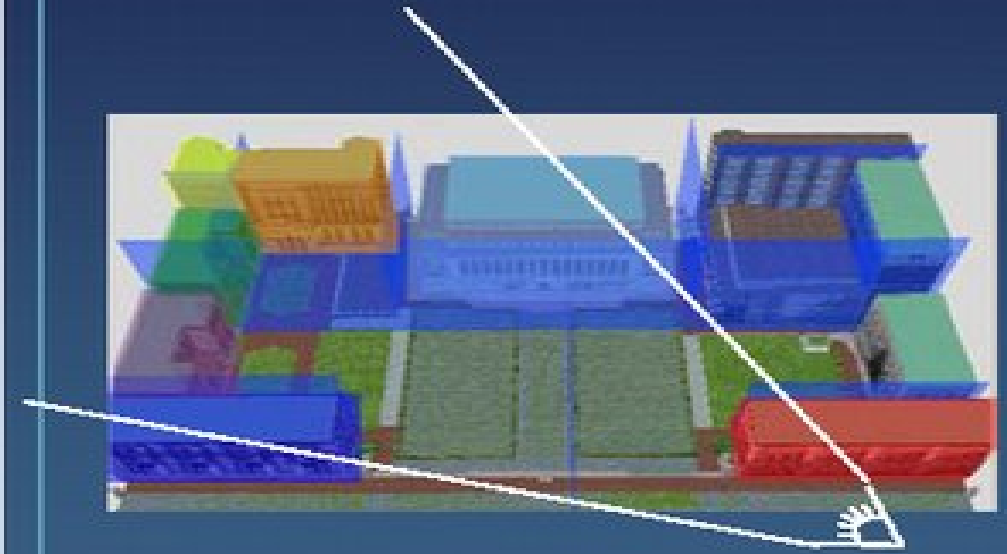
Visible Silhouette Determination (Example)

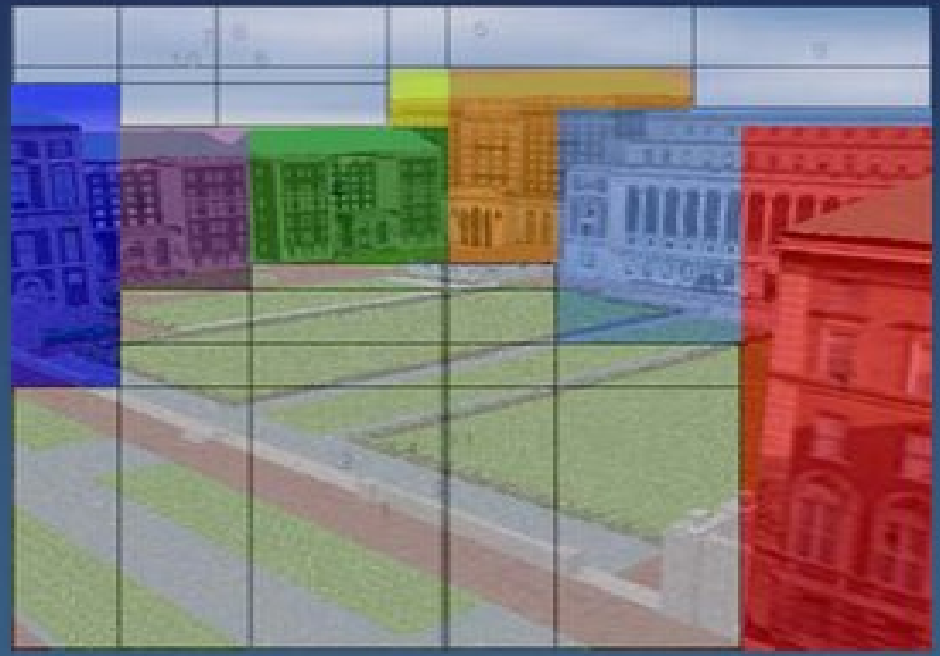




Annotation Algorithm

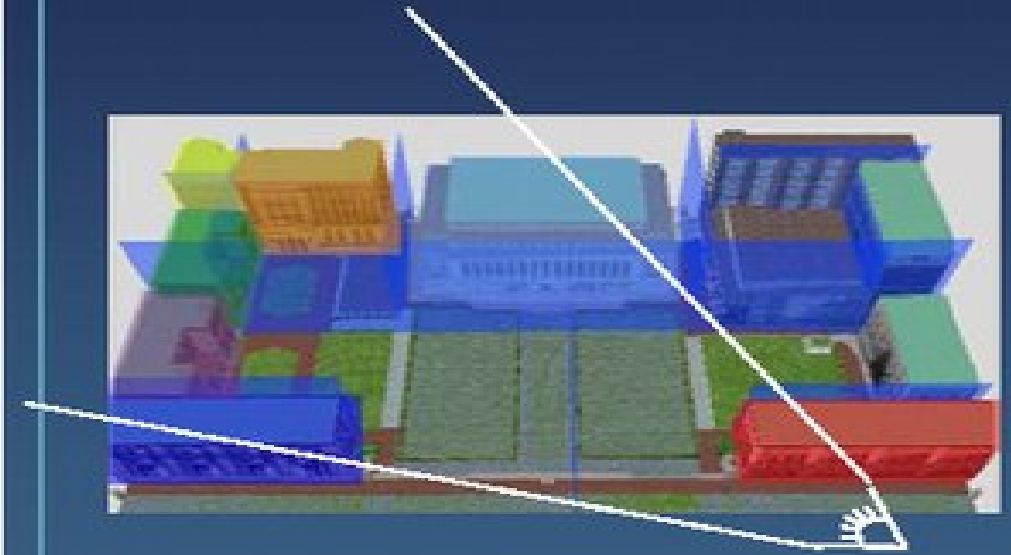
Label Placement (Example)



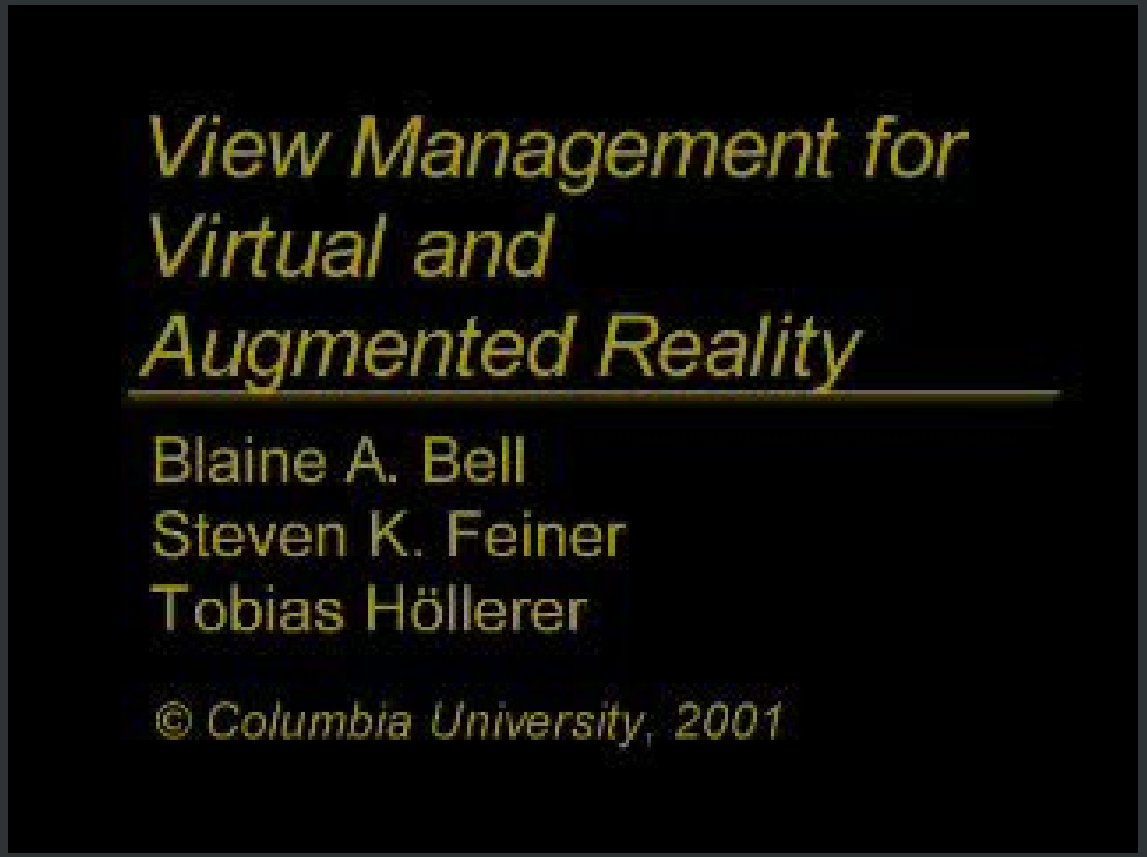


Annotation Algorithm

Label Placement (Example)



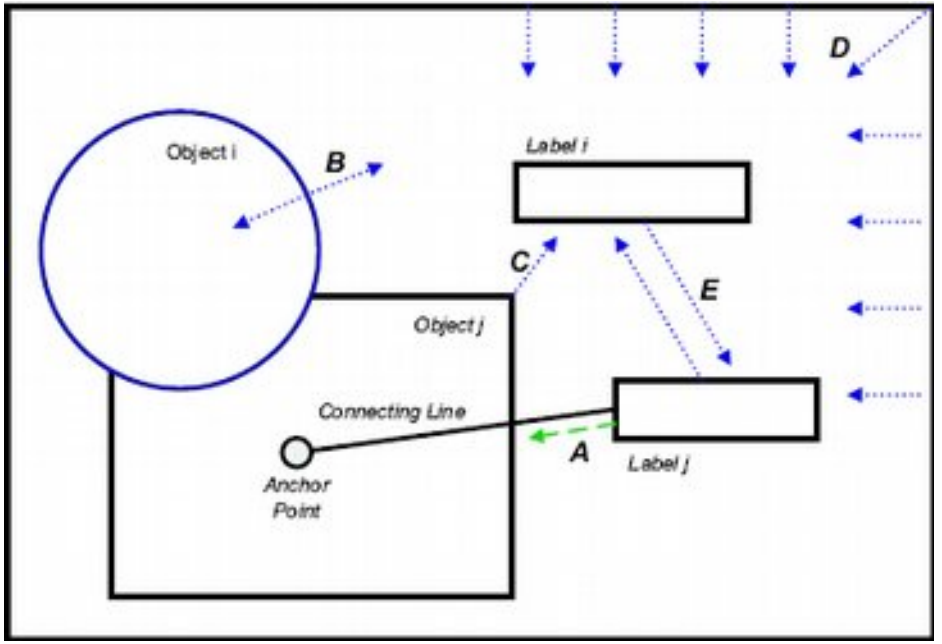
View Management



Force Field Based View Management

- Setup forces between objects

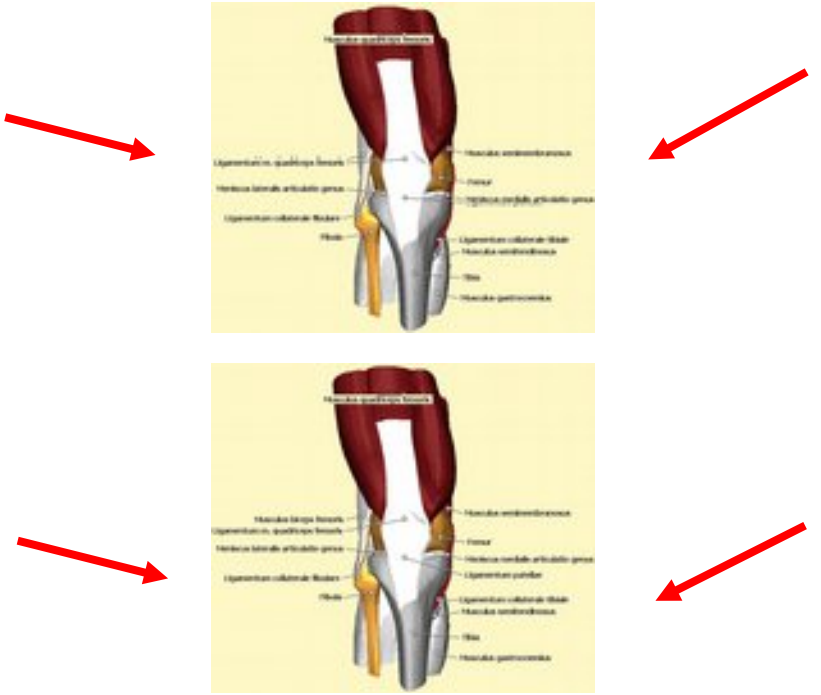
- A: attractive force between a pictorial element and its associated label,
- B: repulsive force at the object boundary (i.e., the label should be placed entirely within or outside its reference object),
- C: repulsive force between the label and all other pictorial elements,
- D: repulsive forces between labels and the image boundary, and
- E: repulsive forces between labels.



[Ali04]

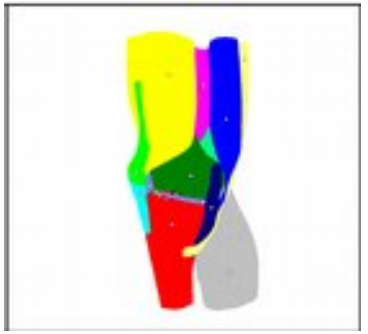
Force Field Based View Management

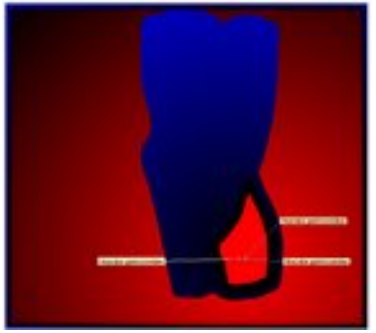
- Place label at initial position
- Use Force field to solve label competition

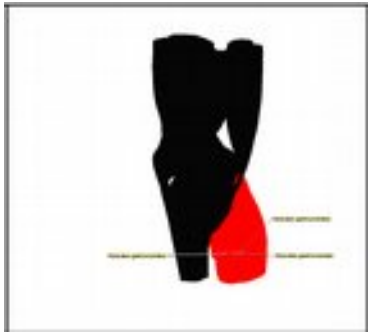


[Ali04]

Force fields



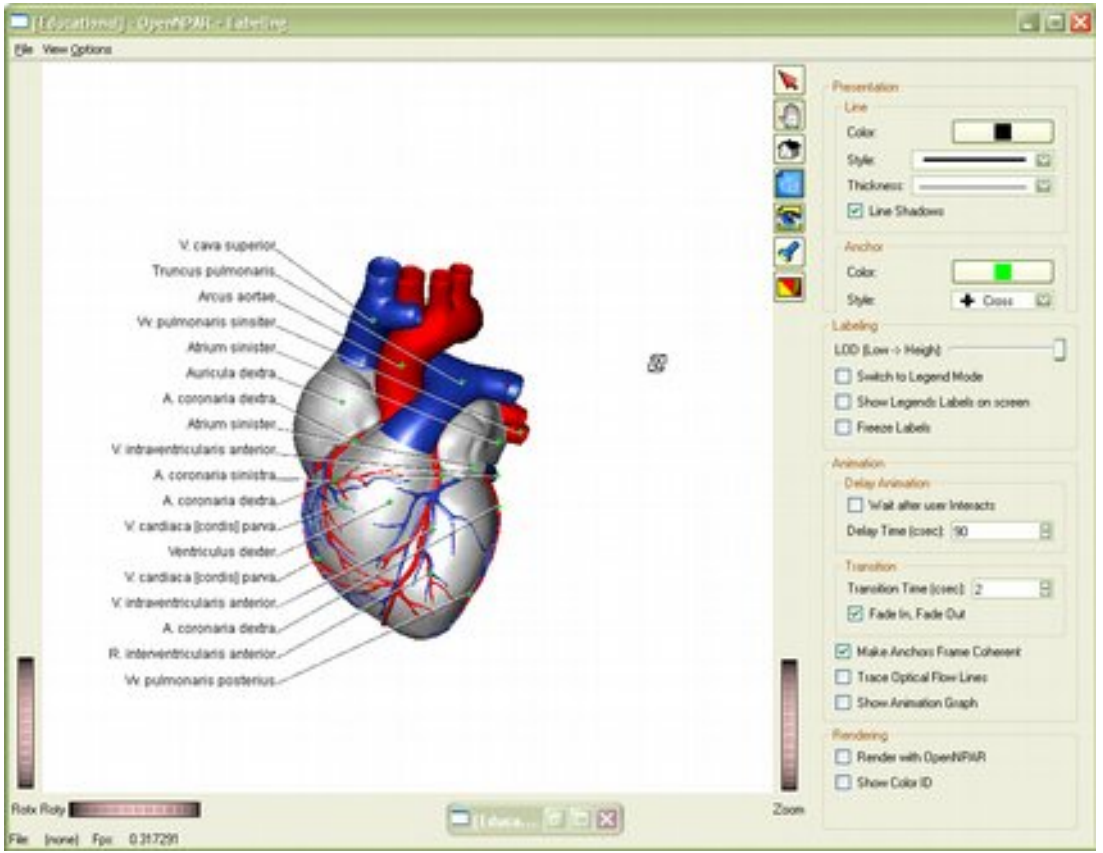




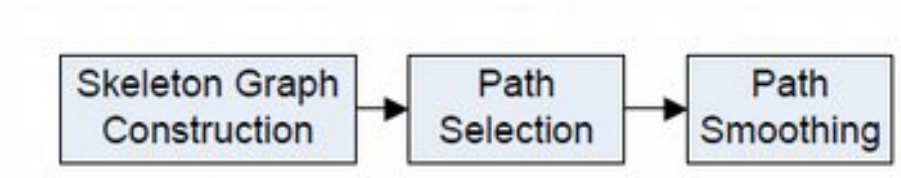
Color-Code:

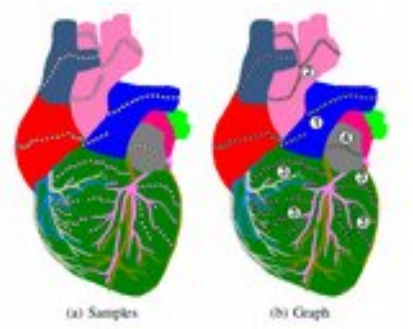
repulsive	neutral	attractive
blue	black	red

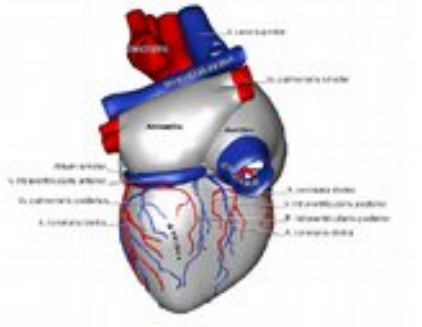
Force based Label Placement



Internal Shape Based







View Management (w. Blaine Bell)

Naïve Annotation

Annotation based on centroids:

misplaced, overlapped, ambiguous

Annotating only visible centroids:

misplaced, overlapped, ambiguous
(but filtered)

View Management (w. Blaine Bell)

Naïve Annotation

Annotation based on centroids:

misplaced, overlapped, ambiguous

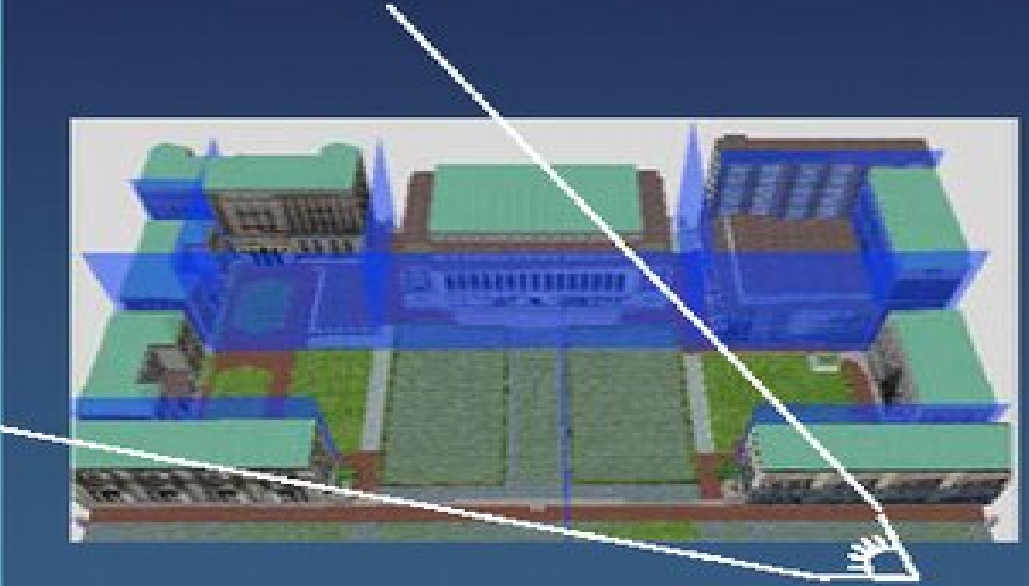
Automated Annotation

Annotating using new algorithm:

correctly placed, overlap and ambiguity avoided

Annotation Algorithm

Visible Silhouette Determination (Example)



Annotation Algorithm

Label Placement (Example)