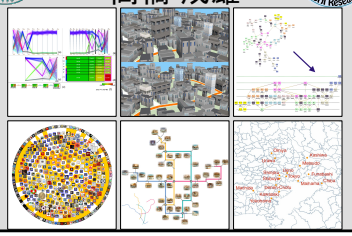
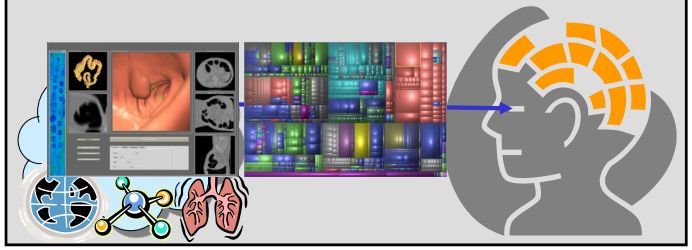
情報可視化における最適化モデルの定式化

会津大学
高橋 成雄



可視化(ビジュアリゼーション)

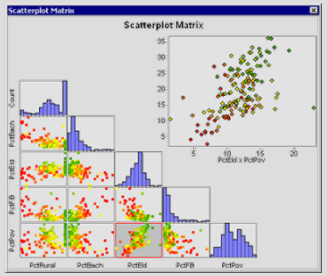
- 複雑な対象データの特徴を
  コンピュータグラフィックス技術を用いて
  効果的に視覚化する技術
- 「百聞は一見にしかず」



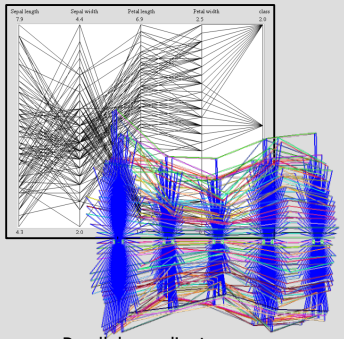
可視化の要素技術

- Scientific Visualization
  科学的可視化
  - 数値データの可視化技法(空間構造あり)
- Information Visualization
  情報可視化
  - 抽象データの可視化技法(空間構造なし)
- Visual Analytics
  視覚分析論
  - 可視化と対話処理の融合による知識発見

多変量データの可視化

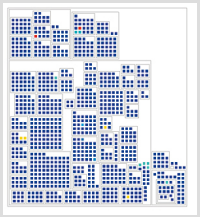


Scatterplot matrix

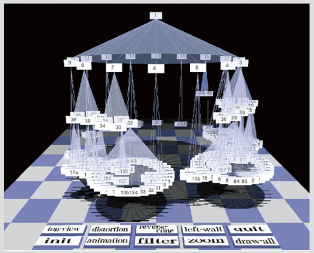


Parallel coordinates

ツリーの可視化

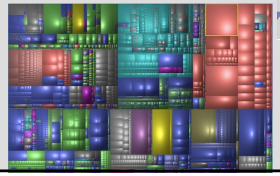


平安京ビュー

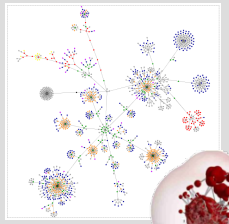


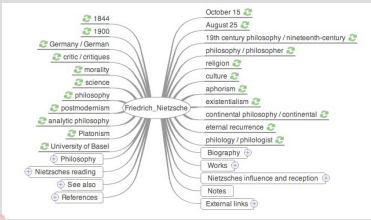
Cone tree

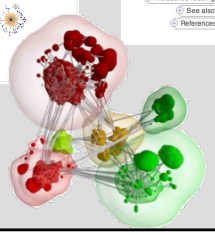
Treemap

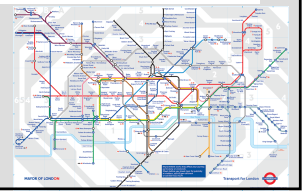


グラフの可視化

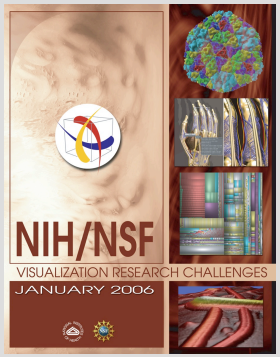








VRC Report

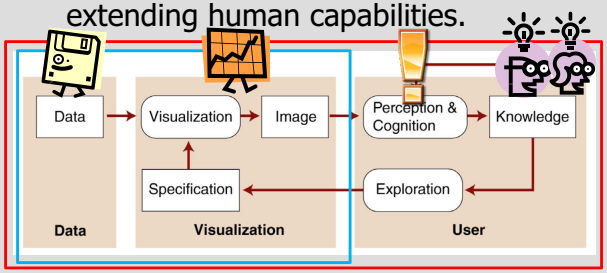


- ViSCレポート(1987)の後継版
- IEEE Vis. 2005 でドラフト配布
- 2006.1 最終版
  http://tab.computer.org/vgtc/vrc/

7

Visualization Discovery Process

- Visualization systems are explicitly designed not to replace the human but to keep the human in the loop by extending human capabilities.



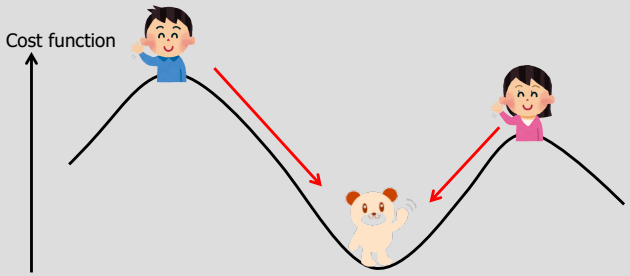
情報可視化の技術的課題

- 最適化問題として定式化
  - データのクラスタリングや分類
  - 視覚表現の図式化およびレイアウト問題
- 個々の解のモデル化は問題ごとに異なる
- 共通の最適化手法が広範囲の問題に適用可能

Overview

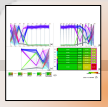
Gradient methods

Gradient Method



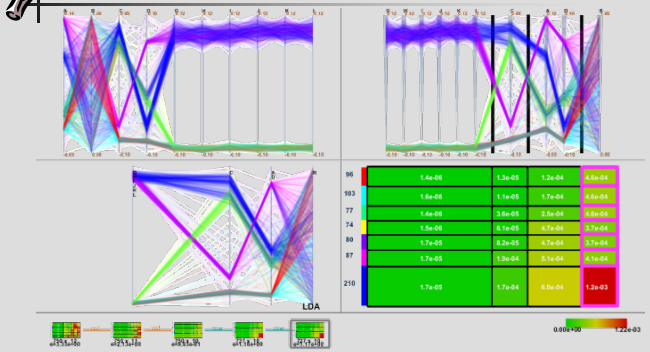
Overview

Gradient methods



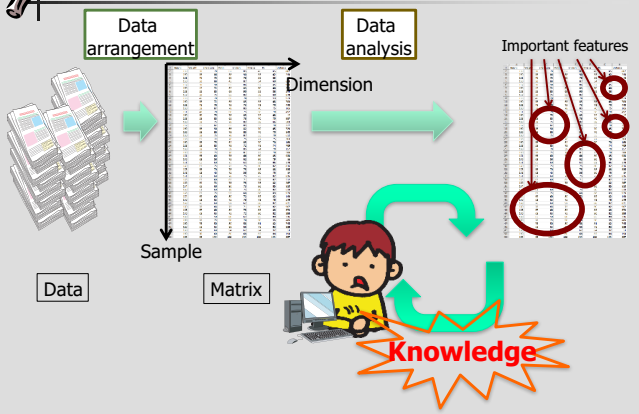
Multivariate analysis

Subspace Mining from High-Dimensional Data
~Asymmetric Biclustering for Finding Data Correlation~

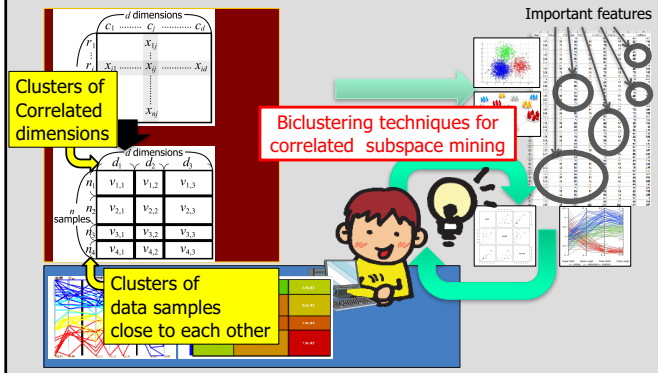


K. Watanabe, H.-Y. Wu, Y. Niibe, S. Takahashi, I. Fujishiro. Biclustering Multivariate Data for Correlated Subspace Mining, Proc. IEEE Pacific Visualization Symposium 2015, 287-294, 2015.

Analyzing Multivariate Data



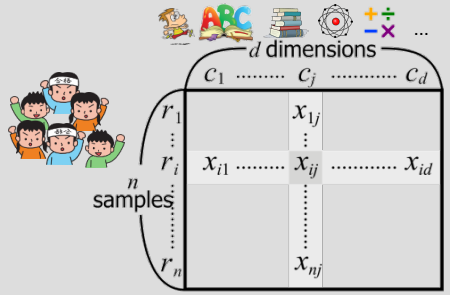
Biclustering Data Samples and Dimensions



Biclustering Method

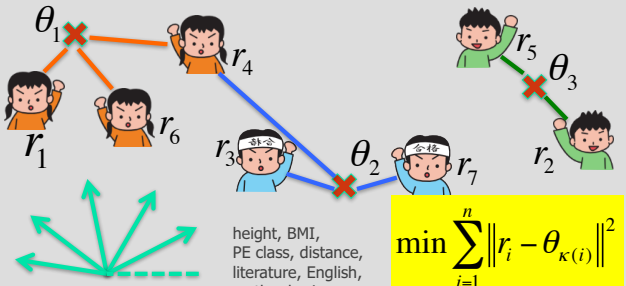
[Hartigan, 1972; van Mechelen et al., 2004]

- Block model



K-means Clustering

- Minimize the sum of distances from the corresponding cluster centers



height, BMI, PE class, distance, literature, English, math, physics, …

$$\min \sum_{i=1}^{n} \left\| r_i - \theta_{\kappa(i)} \right\|^2$$

Biclustering Method

[Hartigan, 1972; van Mechelen et al., 2004]

- Block model
  - Symmetric application of K-means to rows and columns

K-means OK??

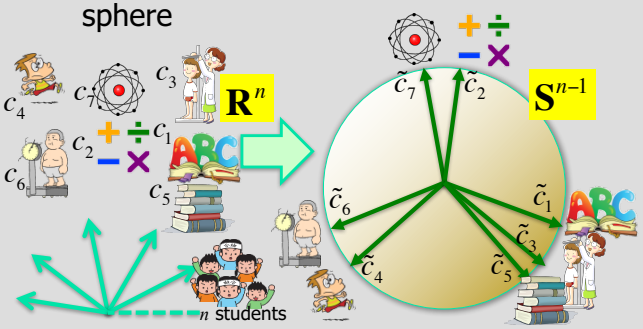
K-means OK!!

$$\min \sum_{i=1}^{n} \sum_{j=1}^{d} (x_{ij} - v_{\kappa(i),\lambda(j)})^2$$

$v_{1,1}$	$v_{1,2}$	$v_{1,3}$
$v_{2,1}$	$v_{2,2}$	$v_{2,3}$
$v_{3,1}$	$v_{3,2}$	$v_{3,3}$
$v_{4,1}$	$v_{4,2}$	$v_{4,3}$

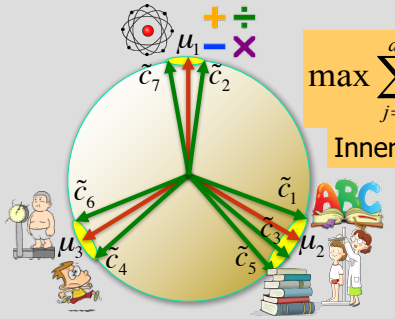
Normalization

- Projected onto a high-dimensional sphere



Spherical K-means Clustering

- Inner product represents correlation

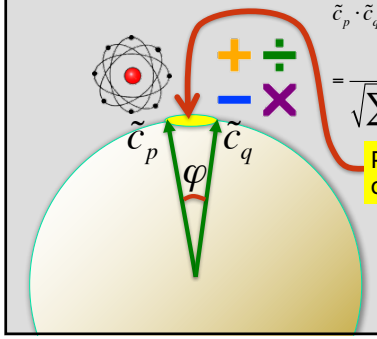


$$\max \sum_{j=1}^{d} \tilde{c}_j \cdot \mu_{\lambda(j)}$$

Inner product

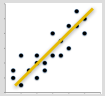
Spherical K-means Clustering

- Inner product represents correlation



$$\tilde{c}_p \cdot \tilde{c}_q = \|\tilde{c}_p\| \|\tilde{c}_q\| \cos\varphi = \frac{\sum_{i=1}^{n} (x_{ip} - \bar{x}_p)(x_{iq} - \bar{x}_q)}{\sqrt{\sum_{i=1}^{n} (x_{ip} - \bar{x}_p)^2} \sqrt{\sum_{i=1}^{n} (x_{iq} - \bar{x}_q)^2}}$$

Pearson product-moment correlation coefficient

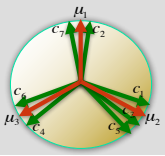


Strongly-correlated

Uncorrelated

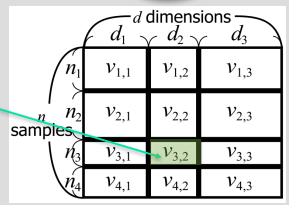
Asymmetric Biclustering

- Iterative algorithm for reducing the objective function monotonically

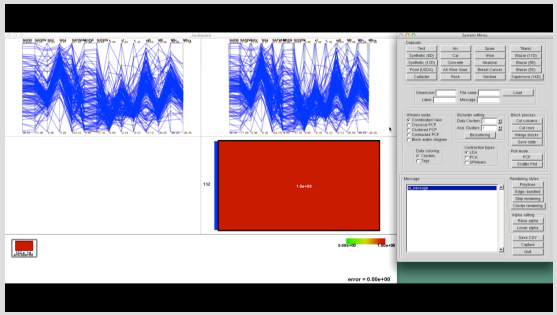


Block error

$$\frac{1}{n_k d_l} \sum_{i:\kappa(i)=k} \sum_{j:\lambda(j)=l} \{\tilde{x}_{ij} - s(j) v_{k,l}\}^2$$



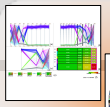
Type Ia Supernova Data

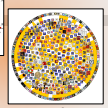


Data is provided by courtesy of Professor Uemura of Hiroshima Univ.

Overview

Gradient methods

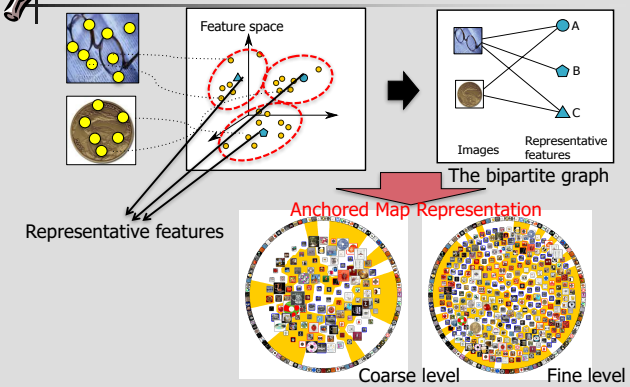




Multivariate analysis

Anchored Maps of Image Feature Space

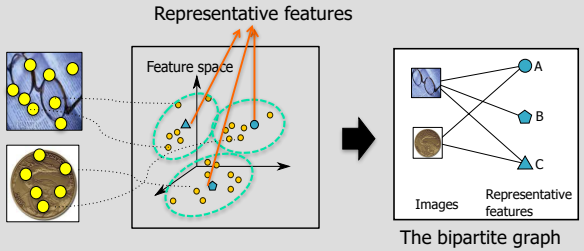
～Projecting High-Dimension through Bipartite Relationships～



Y. Gao, H.-Y. Wu, K. Misue, K. Mizuno, S. Takahashi. Visualizing Bag-of-Feature Image Categorization Using Anchored Maps, Proc. VINCI 2014, 39-48, 2014.

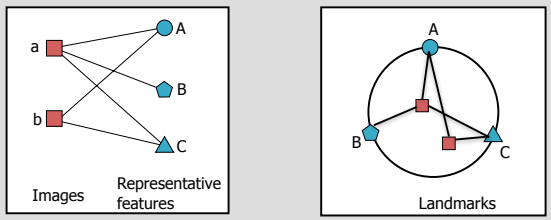
Bag-of-Features Model

- Associate each image with a set of features



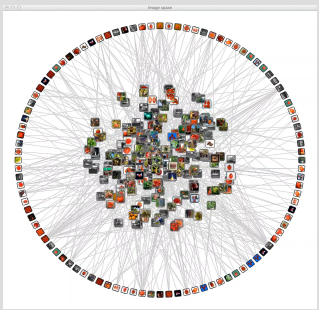
Visualizing Bipartite Relatioships

- Visualize the bipartite graph using anchored map representations



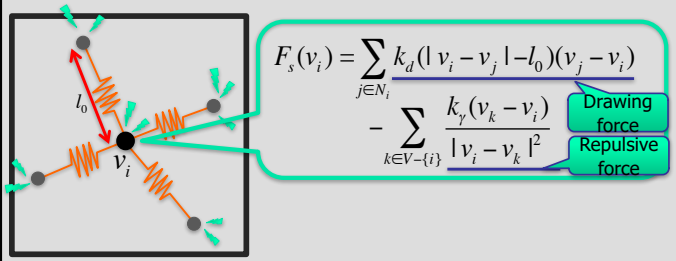
Anchored Map Representation

- Force-directed algorithm is employed



The Force Directed Algorithm

- Avoid excessive visual clutter using drawing and repulsive forces



$$F_s(v_i) = \sum_{j \in N_i} k_d(|v_i - v_j| - l_0)(v_j - v_i) - \sum_{k \in V - \{i\}} \frac{k_r(v_k - v_i)}{|v_i - v_k|^2}$$

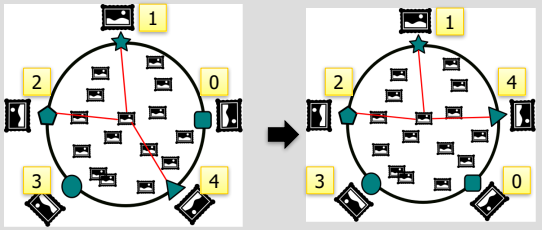
Drawing force

Repulsive force

l_0 : original length

Anchored Map Representation

- Genetic-based optimization
  - improve the visual readability of the anchored map.

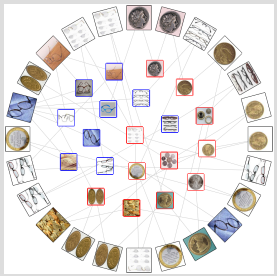


Gene

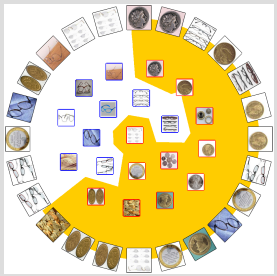
0	1	2	3	4

4	1	2	3	0

Anchored Map Representation



Original layout



With an optimized circular ordering of features

Demonstration

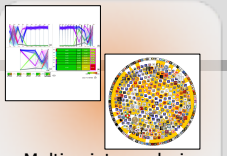
- Discriminate car images from others.

System Demo

Cars, tomatoes, and grapes

Overview

Gradient methods



Multivariate analysis

Linear programming

Linear Programming (LP)

- Inequality constraints

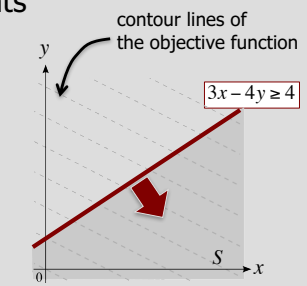
$3x - 4y \geq 4$

$x \leq 6$

$9x + 25y \geq 50$

- Objective function

minimize $c = x + 2y$



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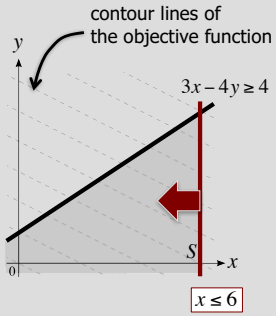

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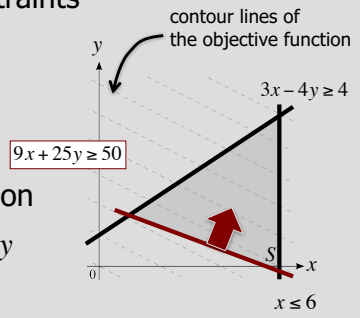

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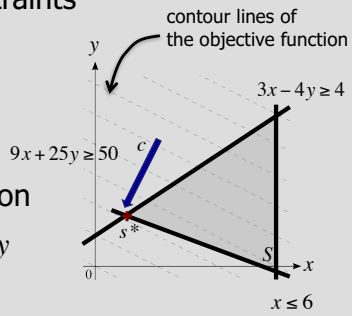
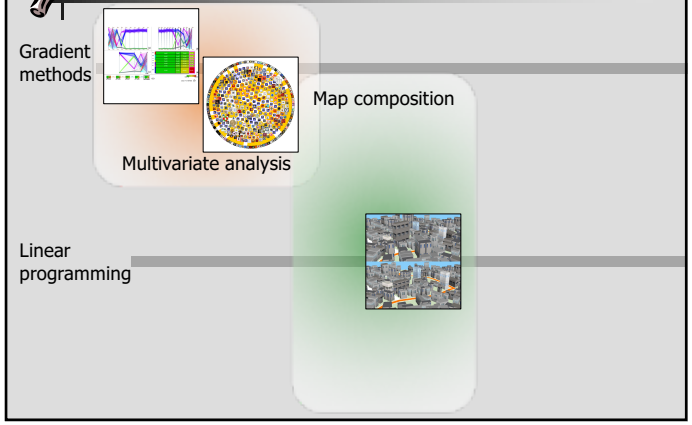
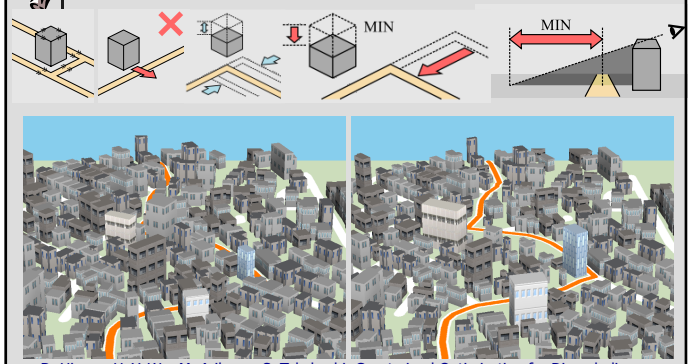


Overview



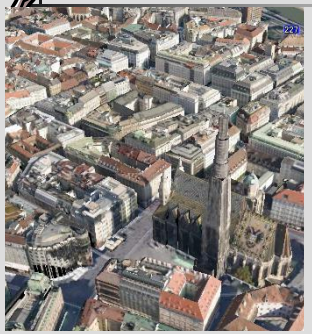
Disoccluding Routes in Urban Maps

~Constrained Optimization for 3D Urban Map Layouts~



D. Hirono, H.-Y. Wu, M. Arikawa, S. Takahashi. Constrained Optimization for Disoccluding Geographical Landmarks in 3D Urban Maps, Proc. IEEE Pacific Visualization Symposium 2013, 17-14, 2013.

Hand-Drawn Urban Maps



Synthesized map
(by Google earth)

Hand-drawn map
(by ATP Jihlava)

Hand-Drawn Urban Maps

Synthesized map
(by Google earth)

Hand-drawn map
(by ATP Jihlava)

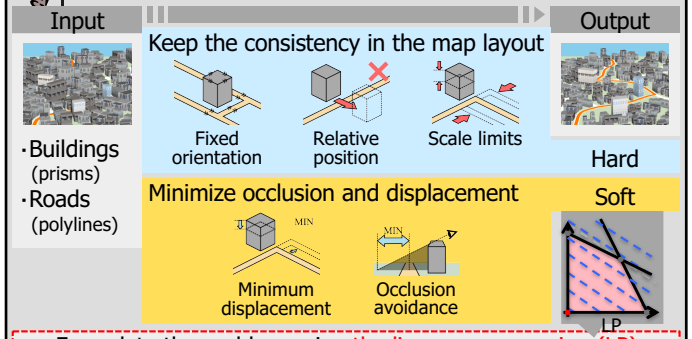
Goal

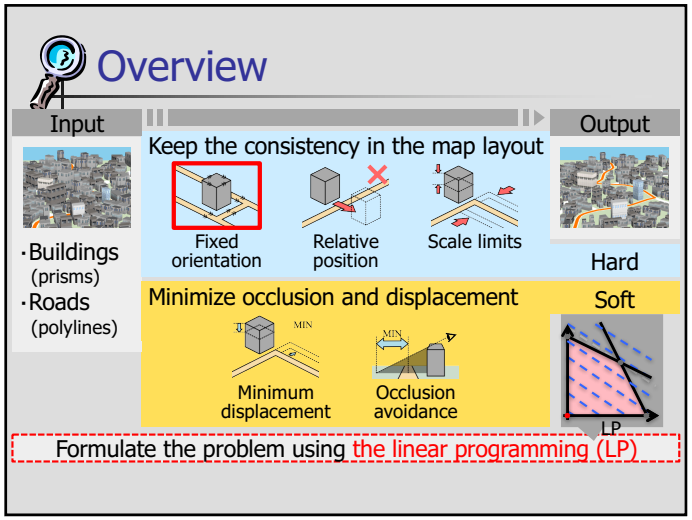
Deform 3D urban maps to enhance their readability

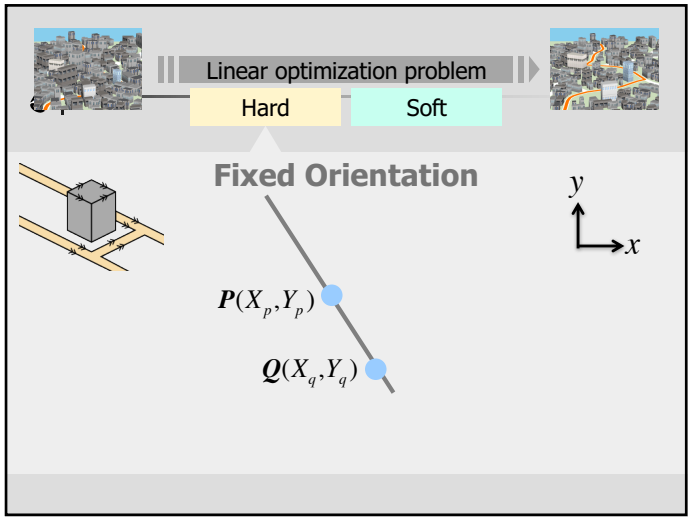
Original layout

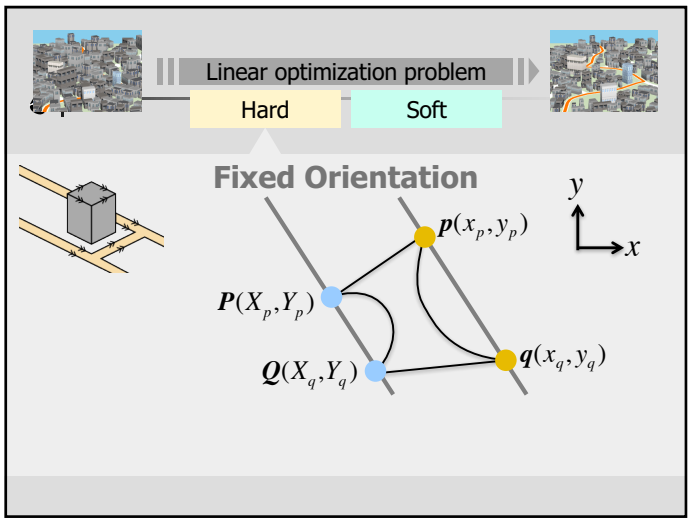
Optimized layout

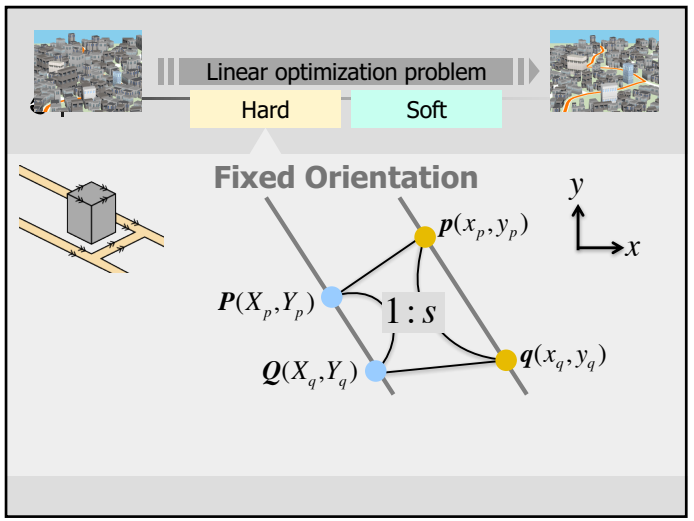
Overview

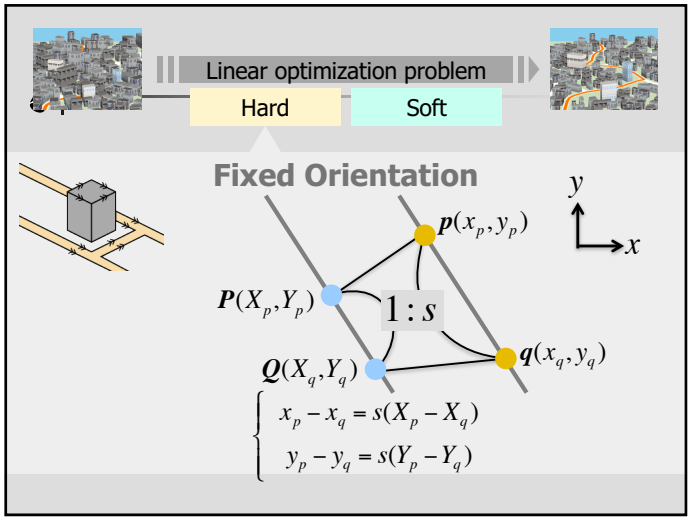


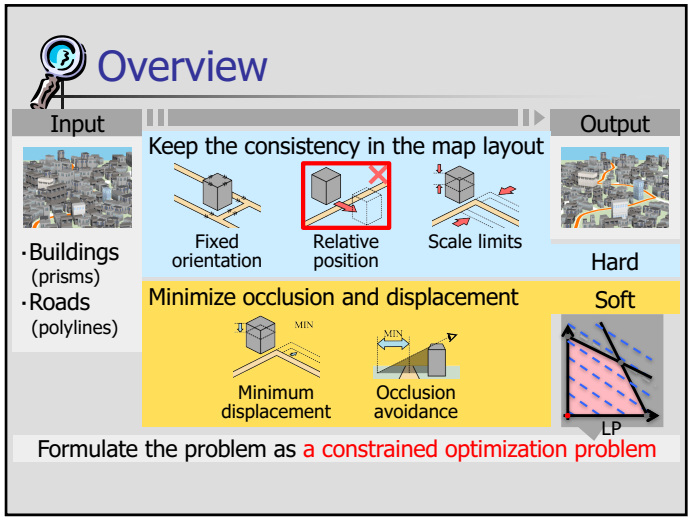

Overview
Input
Output
Keep the consistency in the map layout
Fixed orientation
Relative position
Scale limits
Hard
Buildings (prisms)
Roads (polylines)
Minimize occlusion and displacement
Soft
MIN
Minimum displacement
Occlusion avoidance
LP
Formulate the problem using the linear programming (LP)

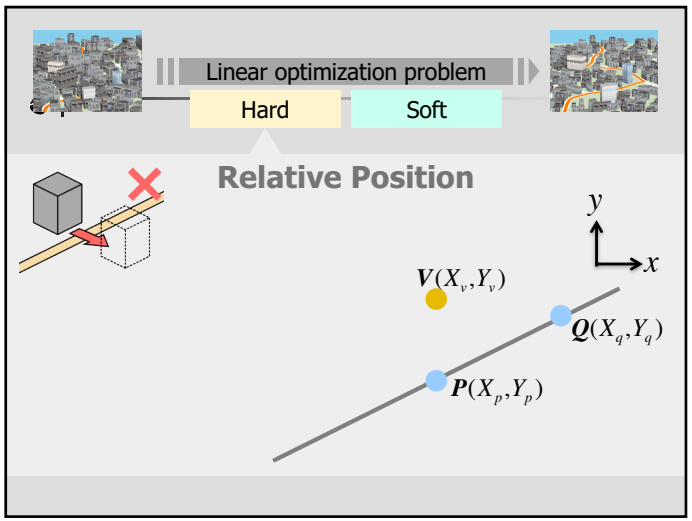

Linear optimization problem
Hard
Soft
Fixed Orientation
y
x
$P(X_p,Y_p)$
$Q(X_q,Y_q)$

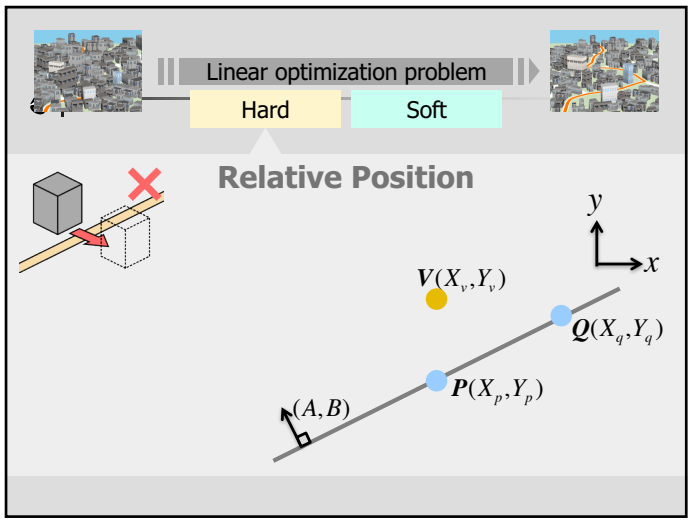

Linear optimization problem
Hard
Soft
Fixed Orientation
y
x
$p(x_p,y_p)$
$P(X_p,Y_p)$
$q(x_q,y_q)$
$Q(X_q,Y_q)$

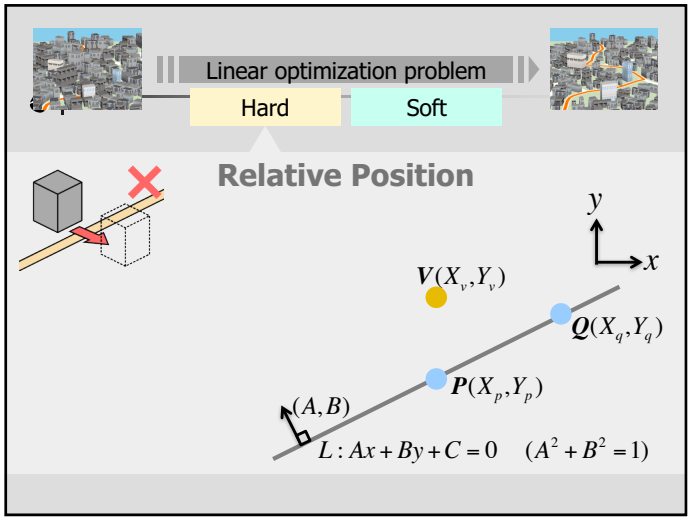

Linear optimization problem
Hard
Soft
Fixed Orientation
y
x
$p(x_p,y_p)$
$P(X_p,Y_p)$
1 : s
$q(x_q,y_q)$
$Q(X_q,Y_q)$

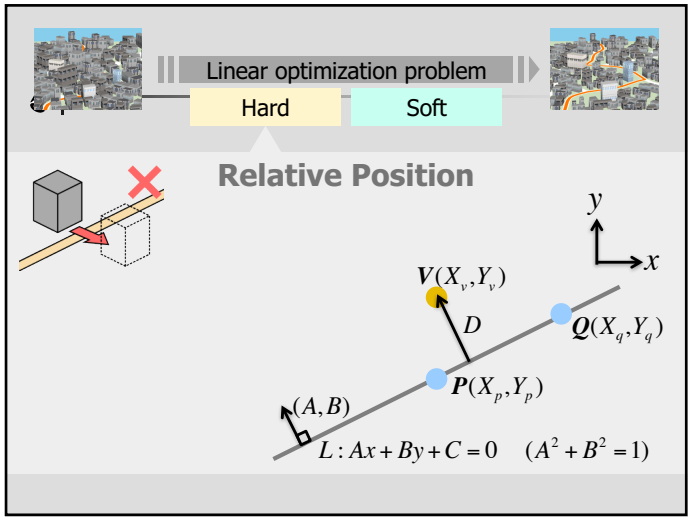

Linear optimization problem
Hard
Soft
Fixed Orientation
y
x
$p(x_p, y_p)$
$P(X_p, Y_p)$
1 : s
$q(x_q, y_q)$
$Q(X_q, Y_q)$
$x_p - x_q = s(X_p - X_q)$
$y_p - y_q = s(Y_p - Y_q)$

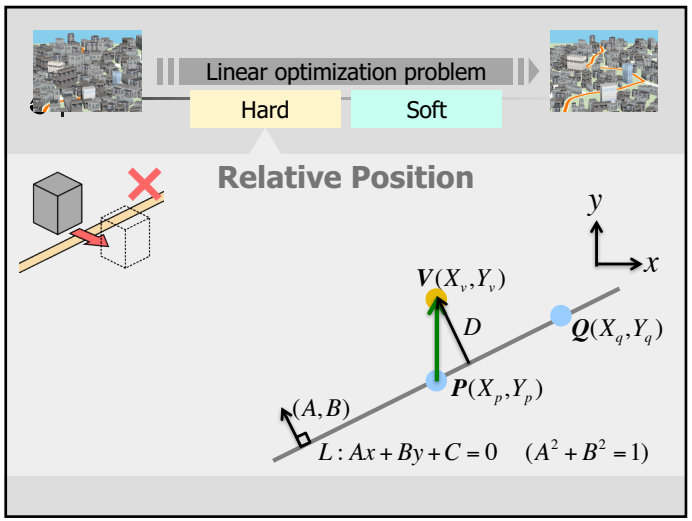

Overview
Input
Output
Keep the consistency in the map layout
Fixed orientation
Relative position
Scale limits
Hard
·Buildings (prisms)
·Roads (polylines)
Minimize occlusion and displacement
Soft
MIN
Minimum displacement
Occlusion avoidance
LP
Formulate the problem as a constrained optimization problem

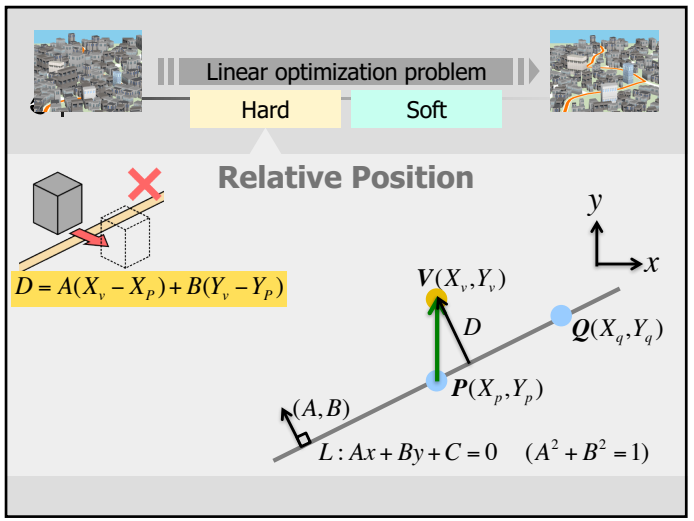

Linear optimization problem
Hard
Soft
Relative Position
y
x
$V(X_v, Y_v)$
$Q(X_q, Y_q)$
$P(X_p, Y_p)$

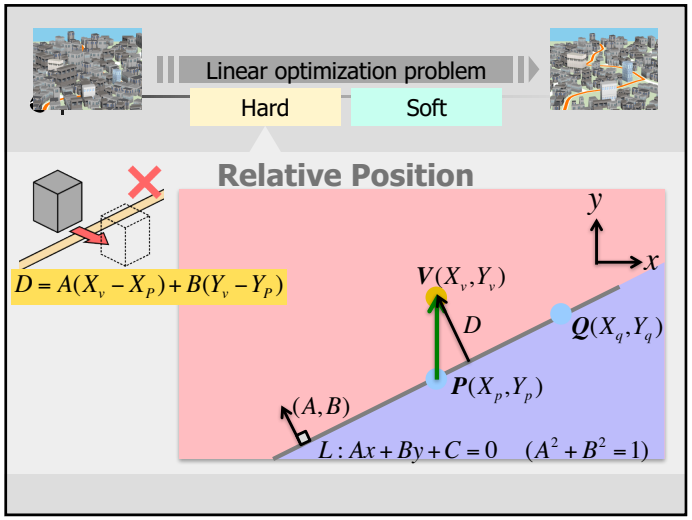

Linear optimization problem
Hard
Soft
Relative Position
y
x
$V(X_v, Y_v)$
$Q(X_q, Y_q)$
$P(X_p, Y_p)$
(A, B)

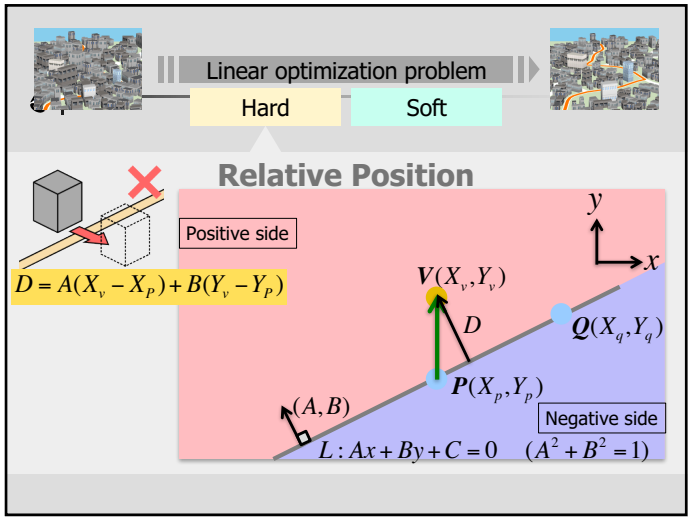

Linear optimization problem
Hard
Soft
Relative Position
y
x
$V(X_v,Y_v)$
$Q(X_q,Y_q)$
$P(X_p,Y_p)$
(A,B)
$L: Ax+By+C=0 \quad (A^2+B^2=1)$

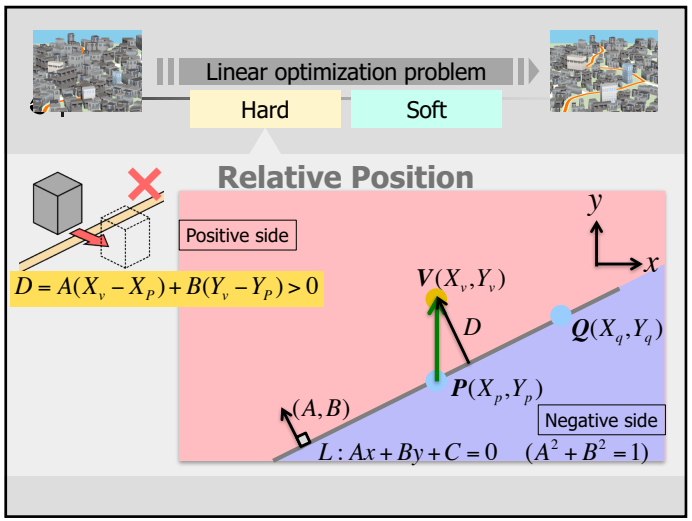

Linear optimization problem
Hard
Soft
Relative Position
y
x
$V(X_v,Y_v)$
D
$Q(X_q,Y_q)$
$P(X_p,Y_p)$
(A,B)
$L: Ax+By+C=0 \quad (A^2+B^2=1)$

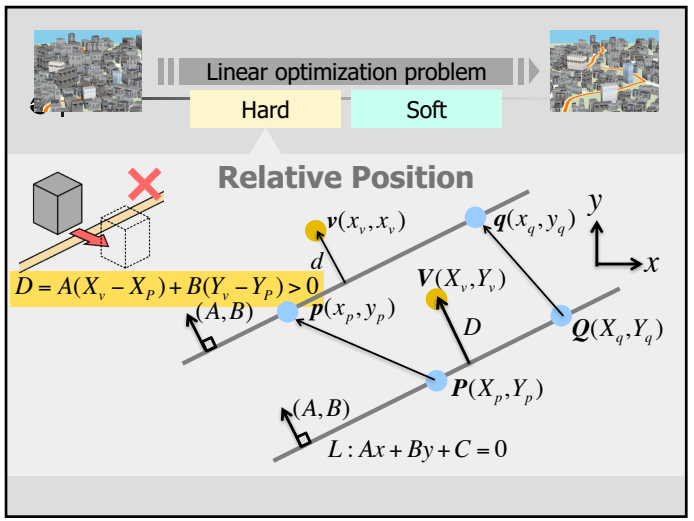

Linear optimization problem
Hard
Soft
Relative Position
y
x
$V(X_v,Y_v)$
D
$Q(X_q,Y_q)$
$P(X_p,Y_p)$
(A,B)
$L: Ax+By+C=0 \quad (A^2+B^2=1)$

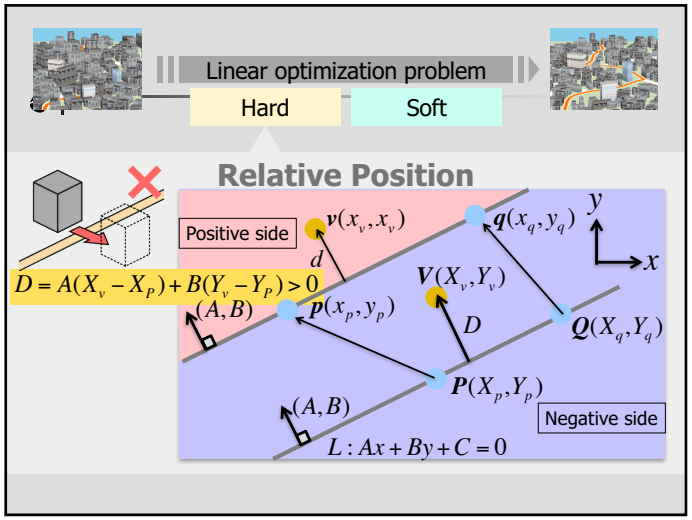

Linear optimization problem
Hard
Soft
Relative Position
$D = A(X_v - X_P) + B(Y_v - Y_P)$
y
x
$V(X_v,Y_v)$
D
$Q(X_q,Y_q)$
$P(X_p,Y_p)$
(A,B)
$L: Ax+By+C=0 \quad (A^2+B^2=1)$

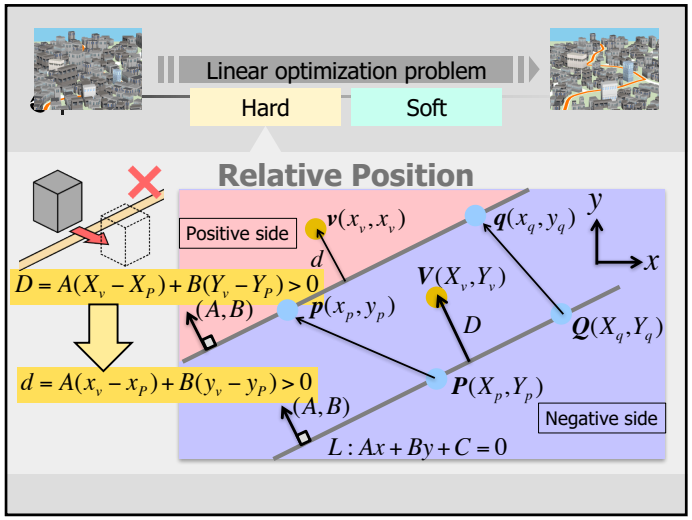

Linear optimization problem
Hard
Soft
Relative Position
$D = A(X_v - X_P) + B(Y_v - Y_P)$
$V(X_v, Y_v)$
D
$Q(X_q, Y_q)$
$P(X_p, Y_p)$
(A, B)
$L : Ax + By + C = 0 \quad (A^2 + B^2 = 1)$
y
x


Linear optimization problem
Hard
Soft
Relative Position
Positive side
$D = A(X_v - X_P) + B(Y_v - Y_P)$
$V(X_v, Y_v)$
D
$Q(X_q, Y_q)$
$P(X_p, Y_p)$
(A, B)
Negative side
$L : Ax + By + C = 0 \quad (A^2 + B^2 = 1)$
y
x

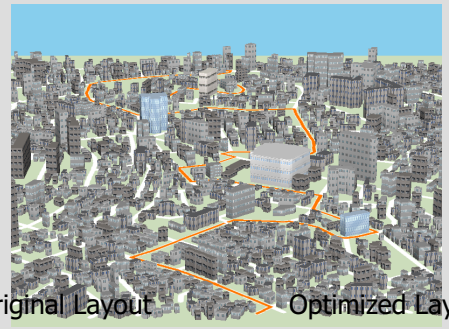

Linear optimization problem
Hard
Soft
Relative Position
Positive side
$D = A(X_v - X_P) + B(Y_v - Y_P) > 0$
$V(X_v, Y_v)$
D
$Q(X_q, Y_q)$
$P(X_p, Y_p)$
(A, B)
Negative side
$L : Ax + By + C = 0 \quad (A^2 + B^2 = 1)$
y
x


Linear optimization problem
Hard
Soft
Relative Position
$v(x_v, x_v)$
$q(x_q, y_q)$
d
$D = A(X_v - X_P) + B(Y_v - Y_P) > 0$
$V(X_v, Y_v)$
(A, B)
$p(x_p, y_p)$
D
$Q(X_q, Y_q)$
$P(X_p, Y_p)$
(A, B)
$L : Ax + By + C = 0$
y
x



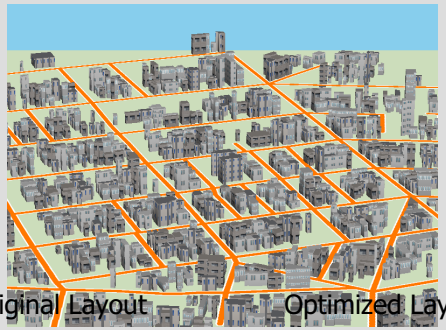


Results: Sharply Curved Route



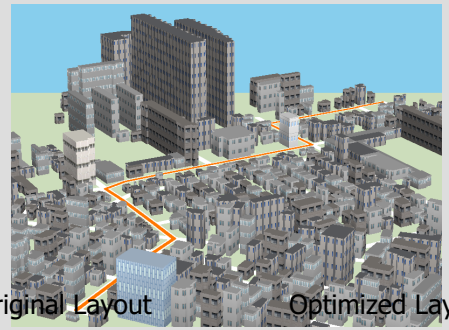
Original Layout Optimized Layout

Results: All the Routes on the Map



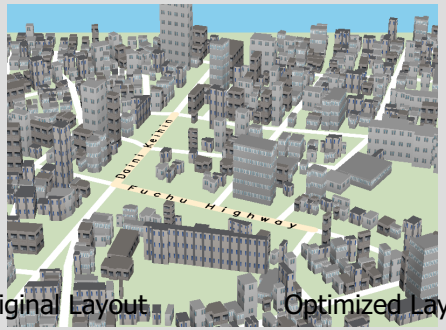
Original Layout Optimized Layout

Results: Landmark Buildings



Original Layout Optimized Layout

Results: Annotating Roads

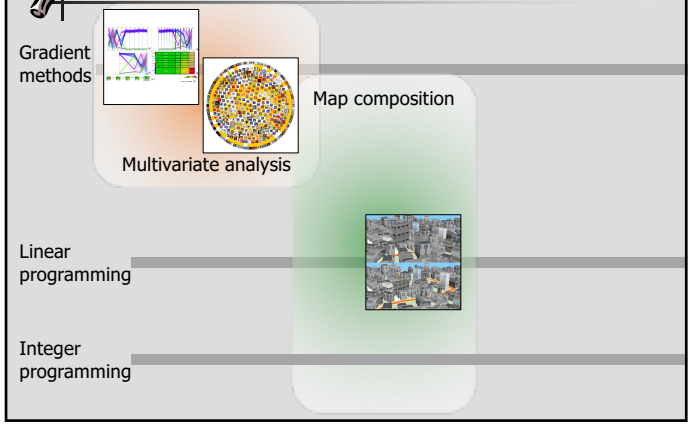


Original Layout Optimized Layout

Results: Statistics

Preprocess	1.2 sec	15.6 sec	6.7 sec	2.4 sec	2.7 sec
Optimization	3.1 sec	53.0 sec	12.7 sec	6.9 sec	8.4 sec
Number of variables	12,372	117,724	45,774	22,363	25,490
Number of constraints	34,057	322,615	105,690	59,067	66,550
Elevation angle	25	20	20	20	30

Overview



Linear Programming (LP)

- Inequality constraints

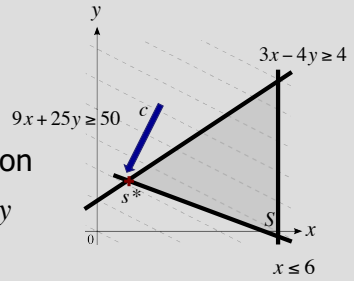
$3x - 4y \geq 4$

$x \leq 6$

$9x + 25y \geq 50$

- Objective function

minimize $c = x + 2y$



Mixed-Integer Programming (MIP)

- Inequality constraints

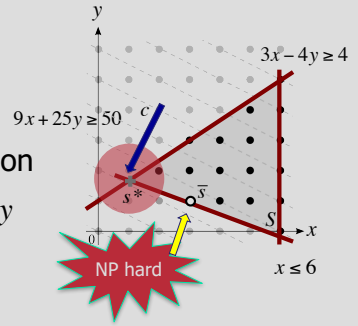
$3x - 4y \geq 4$

$x \leq 6$

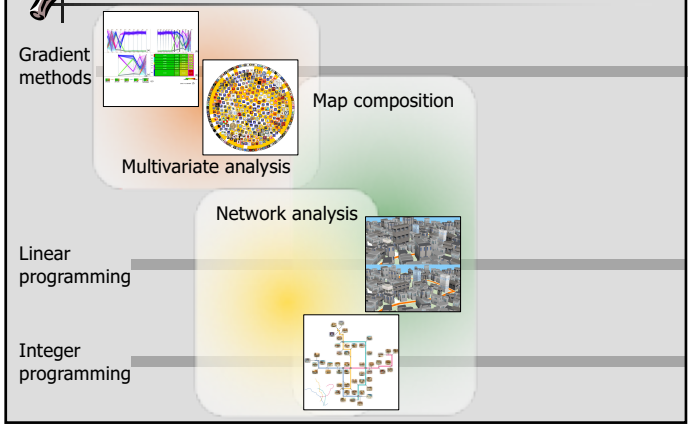
$9x + 25y \geq 50$

- Objective function

minimize $c = x + 2y$

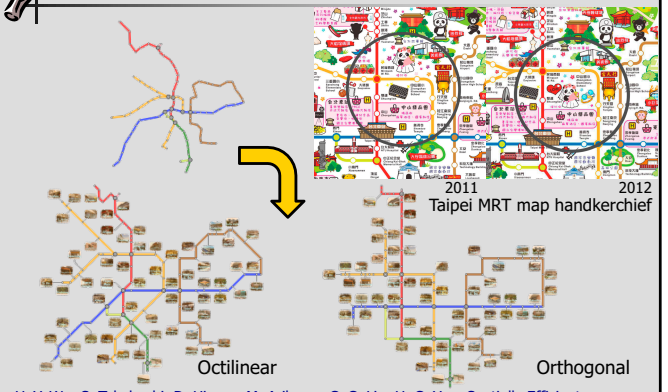


Overview



Spatially-Efficient Metro Map Layout

~Modeling Hand-Drawn Maps as Optimization Problems~



H.-Y. Wu, S. Takahashi, D. Hirono, M. Arikawa, C.-C. Lin, H.-C. Yen. Spatially Efficient Design of Annotated Metro Maps, Computer Graphics Forum, 32(3), 261-270, 2013.

Hand-Drawn Schematic Maps

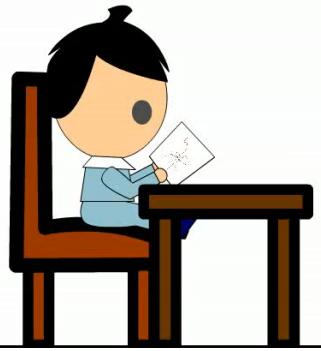
London Underground Map

Hand-Drawn Schematic Maps

Taipei MRT map handkerchief 2012
(Courtegy of Milu Design Co., LTD, Taiwan)

EuroVis 2013, Leipzig, Germany

The Eurographics Conference on Visualization



Map Aesthetic Criteria

Layout

- (LH1) Edge octilinearity
- (LH2) Circular vertex order
- (LH3) Edge spacing
- (LS1) Bend minimization
- (LS2) Relative position minimization
- (LS3) Edge length minimization

Harry Beck, 1933

Map Aesthetic Criteria

Layout

- (LH1) Edge octilinearity
- (LH2) Circular vertex order
- (LH3) Edge spacing
- (LS1) Bend minimization
- (LS2) Relative position minimization
- (LS3) Edge length minimization

Annotation

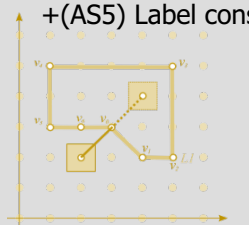
- (AH1) Leader octilinearity
- (AH2) Overlap-free layout
- (AS1) Leader orientation
- (AS2) Total leader length
- (AS3) Leader bends
- (AS4) Closed regions
- (AS5) Alternating distribution

Harry Beck, 1933

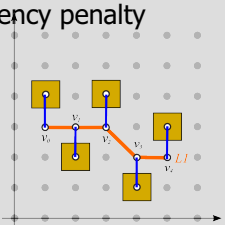
Spatially efficient annotated map

Soft Constraints

- C=(AS1) Leader orientation penalty
  +(AS2) Leader length penalty
  +(AS3) Leader bend penalty
  +(AS4) Closed region penalty
  +(AS5) Label consistency penalty



(AS4) Closed region penalty



(AS5) Label consistency penalty

Label Consistency Penalty

For each enclosed region

$$\text{cost}_{(AS5)} = \sum_{j \in I_j} \text{adj}(f_j)$$

$$(f_j(v_i)) \text{XOR} (f_j(v_{i+1})) = (f_j(v_i) \text{AND} \overline{f_j(v_{i+1})}) \text{OR} (\overline{f_j(v_i)} \text{AND} f_j(v_{i+1}))$$

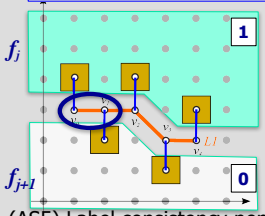
$$2a_i \le 1 + f_j(v_i) - f_j(v_{i+1}) \le 1 + a_i \quad \text{AND}$$

$$2b_i \le 1 - f_j(v_i) + f_j(v_{i+1}) \le 1 + b_i \quad \text{AND}$$

$$1 - \text{adj}_i(f_j) \le a_i + b_i \le 2(1 - \text{adj}_i(f_j)) \quad \text{OR}$$

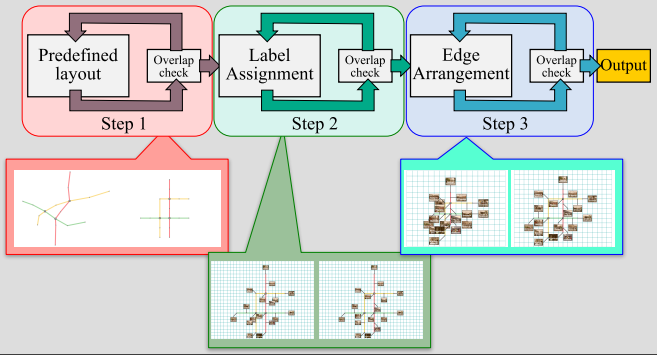
$$\text{AND} \quad 2x \le x_1 + x_2 \le 1 + x$$

$$\text{OR} \quad x \le x_1 + x_2 \le 2x$$



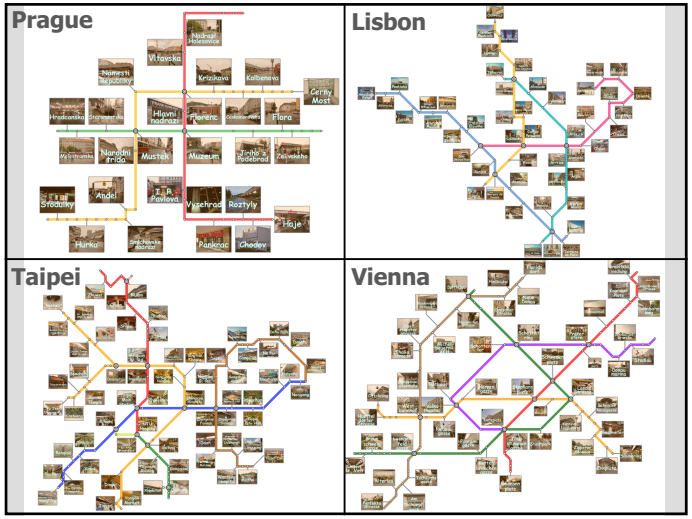
(AS5) Label consistency penalty

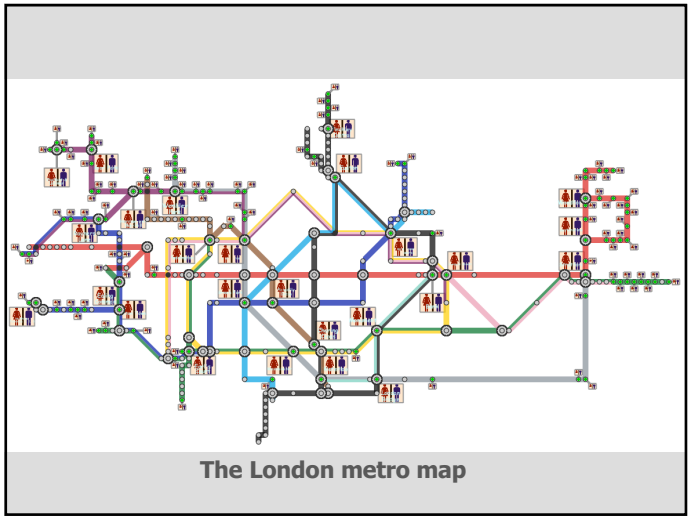
Three-Step Algorithm



Demonstration

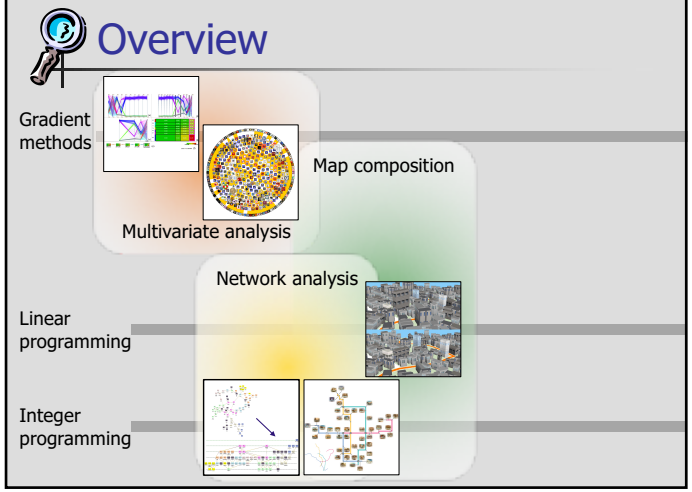
Design Scenario

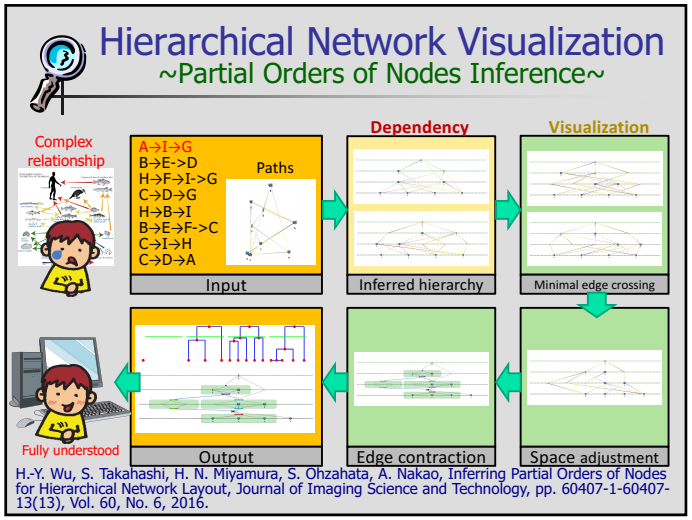


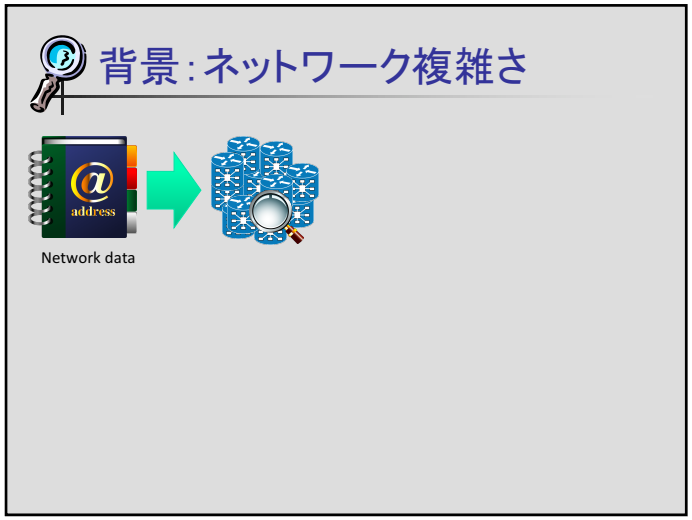


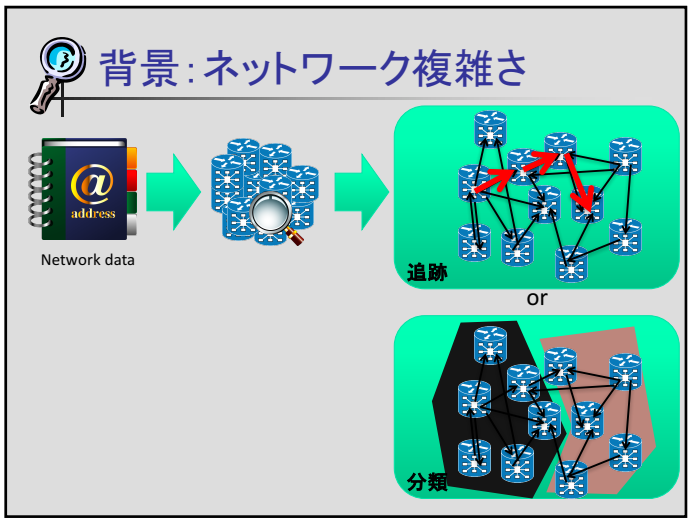
The London metro map

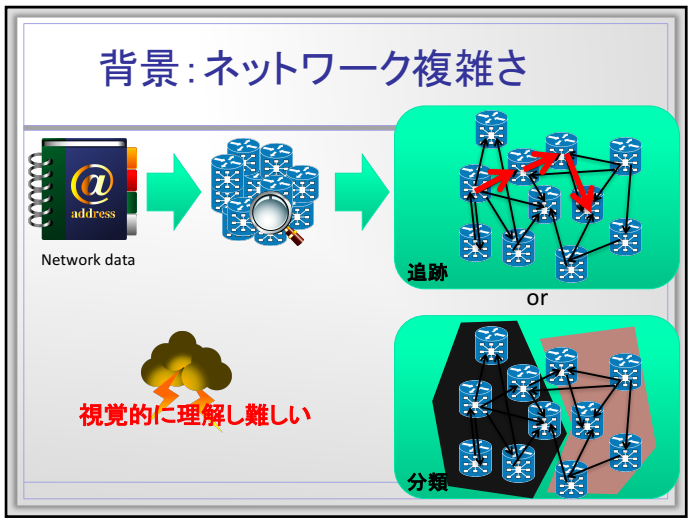
Overview



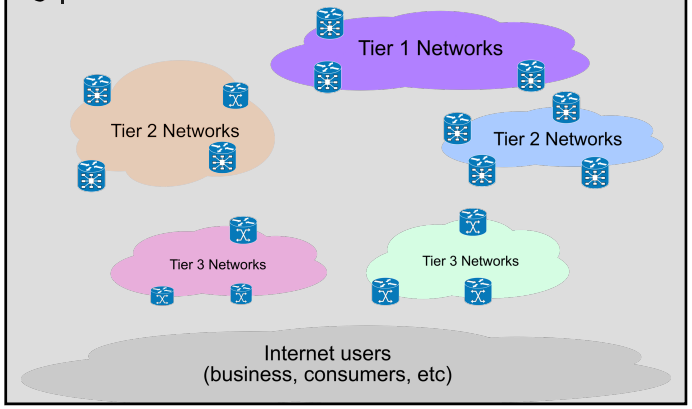

Hierarchical Network Visualization
~Partial Orders of Nodes Inference~
Complex relationship
A→I→G
B→E->D
H→F→I->G
C→D→G
H→B→I
B→E→F->C
C→I→H
C→D→A
Paths
Input
Dependency
Inferred hierarchy
Visualization
Minimal edge crossing
Space adjustment
Edge contraction
Output
Fully understood
H.-Y. Wu, S. Takahashi, H. N. Miyamura, S. Ohzahata, A. Nakao, Inferring Partial Orders of Nodes for Hierarchical Network Layout, Journal of Imaging Science and Technology, pp. 60407-1-60407-13(13), Vol. 60, No. 6, 2016.


背景：ネットワーク複雑さ
address
Network data

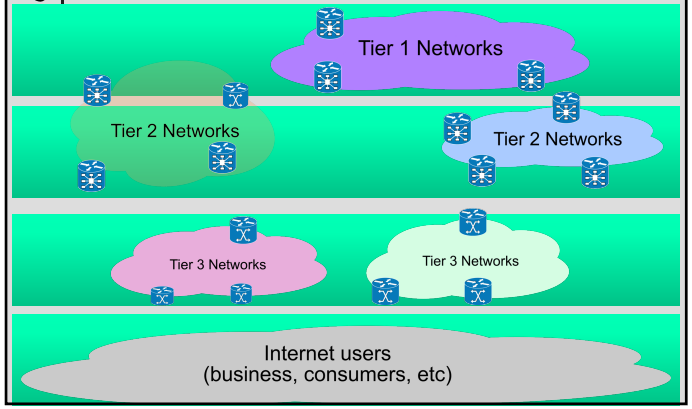

背景：ネットワーク複雑さ
address
Network data
追跡
or
分類


背景：ネットワーク複雑さ
address
Network data
追跡
or
視覚的に理解し難しい
分類

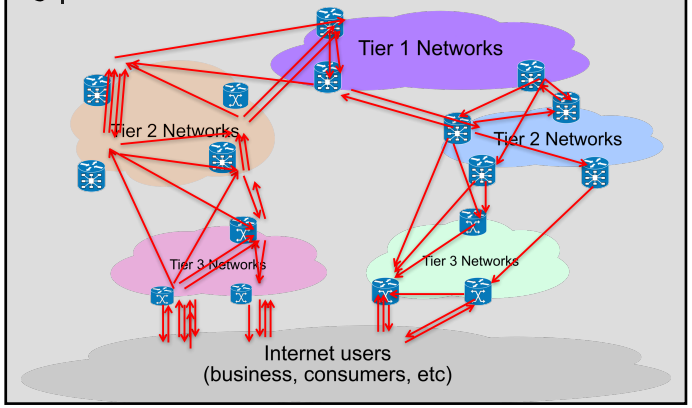
考察：現実のネットワーク



考察：現実のネットワーク

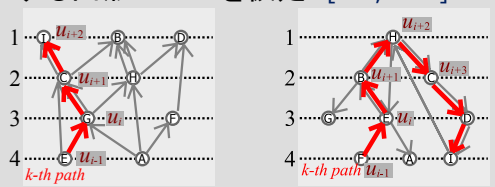


問題:階層構造の推測と可視化



アイデア: ネットワークパスから推測

- 片道パス：パスがネットワーク階層を順々に登るものを仮定．
- 往復パス：低階層，高階層，低階層と移動する山形のパスを仮定．[Gao, 2001]



片道パス　往復パス

整数計画法による最適化を用いて類推する

手法：片道パス

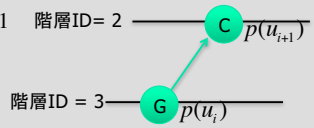
E→G→C->I
E→C->B
A→G→H->B
A→H→D
A→F→D
入力

ペナルティー，小さければよい．

$$p(u_i) - p(u_{i+1}) \geq 1 - v_{i,i+1}$$

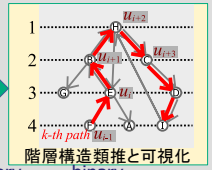
$$p(u_i) - p(u_{i+1}) \leq \lambda_{i,i+1}$$

階層IDの差，
小さければよい．



手法：往復パス

F→E→B->H->C->D->I
I→H→C→D->I
I→H→E->A
F→E→B->G
入力

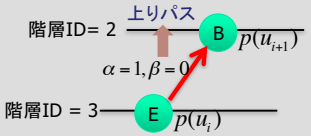


上りパス

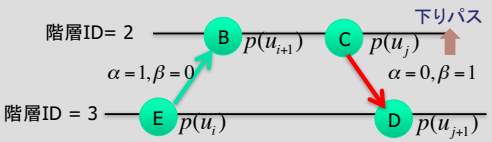
binary binary

$$p(u_i) - p(u_{i+1}) \geq +\alpha_{i,i+1} - M\beta_{i,i+1} - v_{i,i+1}$$

$$p(u_i) - p(u_{i+1}) \leq \lambda_{i,i+1}$$



手法：往復パス



上りパス

$$p(u_i) - p(u_{i+1}) \geq +\alpha_{i,i+1} - M\beta_{i,i+1} - v_{i,i+1}$$

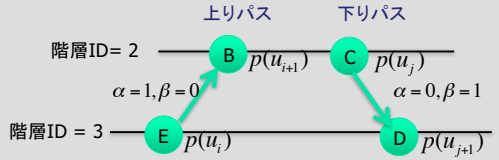
$$p(u_i) - p(u_{i+1}) \leq \lambda_{i,i+1}$$

下りパス

$$p(u_j) - p(u_{j+1}) \leq -\beta_{j,j+1} + M\alpha_{j,j+1} + v_{j,j+1}$$

$$p(u_j) - p(u_{j+1}) \geq -\lambda_{j,j+1}$$

手法：往復パス



上りパス

$$p(u_i) - p(u_{i+1}) \geq +\alpha_{i,i+1} - M\beta_{i,i+1} - v_{i,i+1}$$

$$p(u_i) - p(u_{i+1}) \leq \lambda_{i,i+1}$$

上りパスと下りパスは両立はしないため，
大きい整数Mを導入

下りパス

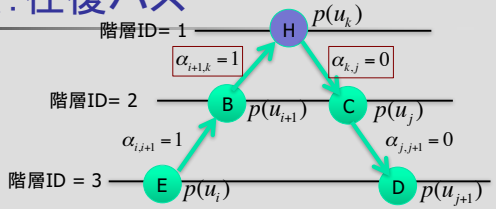
$$p(u_j) - p(u_{j+1}) \leq -\beta_{j,j+1} + M\alpha_{j,j+1} + v_{j,j+1}$$

$$p(u_j) - p(u_{j+1}) \geq -\lambda_{j,j+1}$$

$$\alpha_{j,j+1} + \beta_{j,j+1} = 1$$

手法：往復パス

ターニングポイントは1つ (山形)



上りパス

$$p(u_i)-p(u_{i+1}) \geq +\alpha_{i,i+1}-M\beta_{i,i+1}-v_{i,i+1}$$

$$p(u_i)-p(u_{i+1}) \leq \lambda_{i,i+1}$$

下りパス

$$p(u_j)-p(u_{j+1}) \leq -\beta_{j,j+1}+M\alpha_{j,j+1}+v_{j,j+1}$$

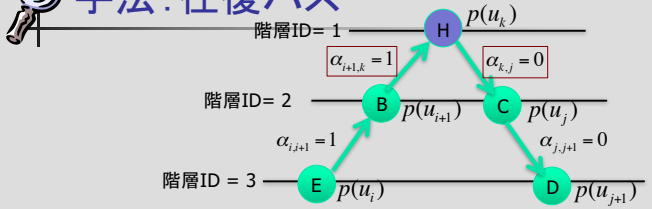
$$p(u_j)-p(u_{j+1}) \geq -\lambda_{j,j+1}$$

$$\alpha_{j,j+1}+\beta_{j,j+1}=1$$

$$\alpha_{i,i+1} \oplus \alpha_{i+1,k}+\alpha_{i+1,k} \oplus \alpha_{k,j}+\alpha_{k,j} \oplus \alpha_{j,j+1}=1 \quad \oplus(XOR)$$

手法：往復パス

ターニングポイントは1つ (山形)



上りパス

$$p(u_i)-p(u_{i+1}) \geq +\alpha_{i,i+1}-M\beta_{i,i+1}-v_{i,i+1}$$

$$p(u_i)-p(u_{i+1}) \leq \lambda_{i,i+1}$$

下りパス

$$p(u_j)-p(u_{j+1}) \leq -\beta_{j,j+1}+M\alpha_{j,j+1}+v_{j,j+1}$$

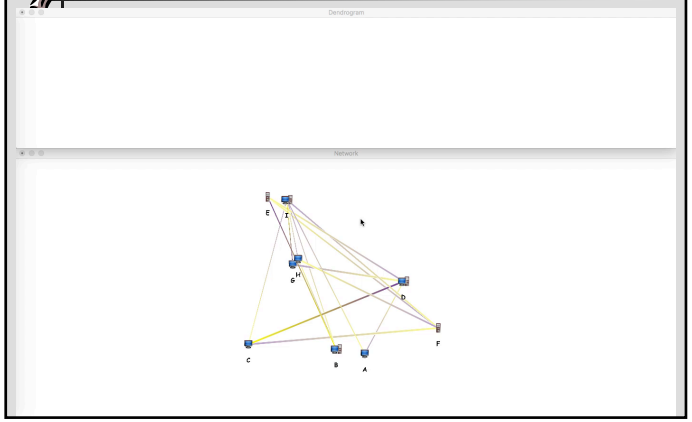
$$p(u_j)-p(u_{j+1}) \geq -\lambda_{j,j+1}$$

$$\alpha_{j,j+1}+\beta_{j,j+1}=1$$

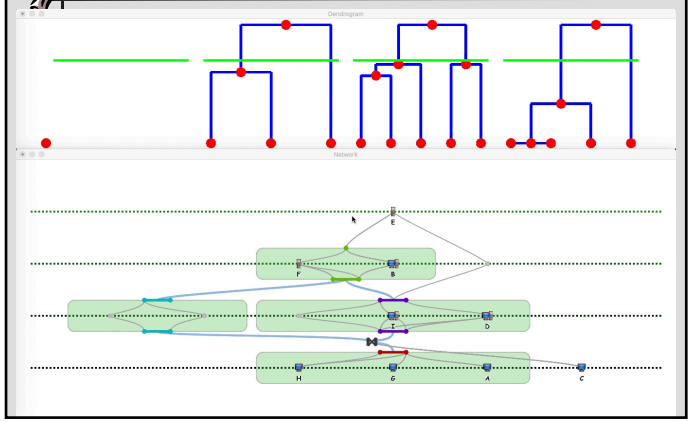
最小化 $\text{minimize } w_1 \times \lambda_{i,i+1}+w_2 \times v_{i,i+1}$

$$\alpha_{i,i+1} \oplus \alpha_{i+1,k}+\alpha_{i+1,k} \oplus \alpha_{k,j}+\alpha_{k,j} \oplus \alpha_{j,j+1}=1 \quad \oplus(XOR)$$

A Short Demonstration

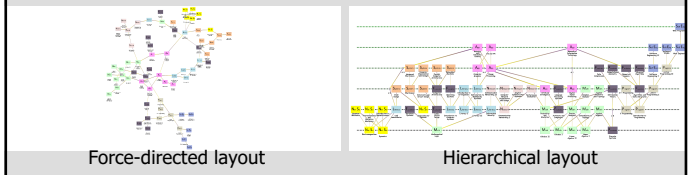


User Intervention

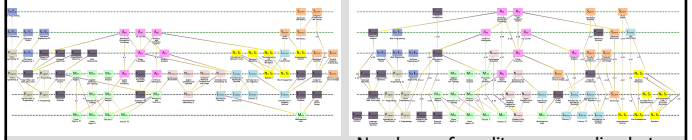


Applications 1: One-way Path

- Curricula of Univ. of Aizu



Force-directed layout | Hierarchical layout

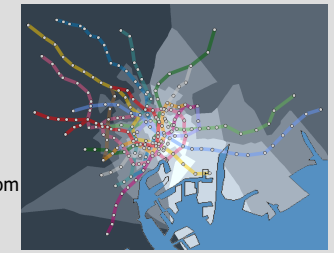


Reverse paths are more penalized | Numbers of credits are equalized at the respective layers

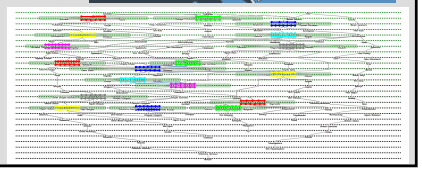
Applications 2: Round-trip Path

- Tokyo metro
  - 255 stations
  - 13 metro lines

Accessibility zones inferred from the metro network

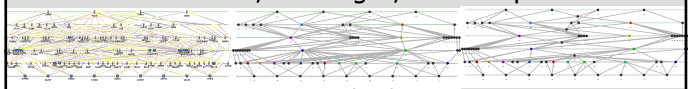


Visualizing hierarchies among the metro stations

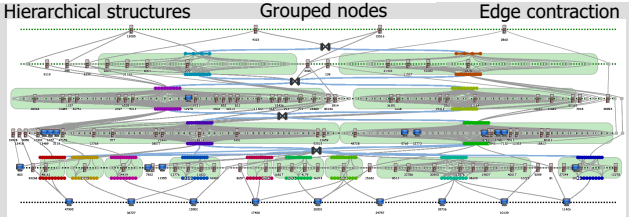


Applications 3: Round-trip Path

- P2P network
  - 116 nodes, 306 edges, and 525 paths

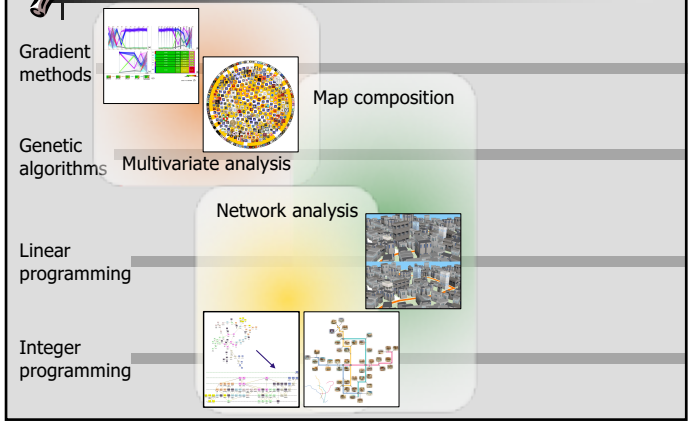


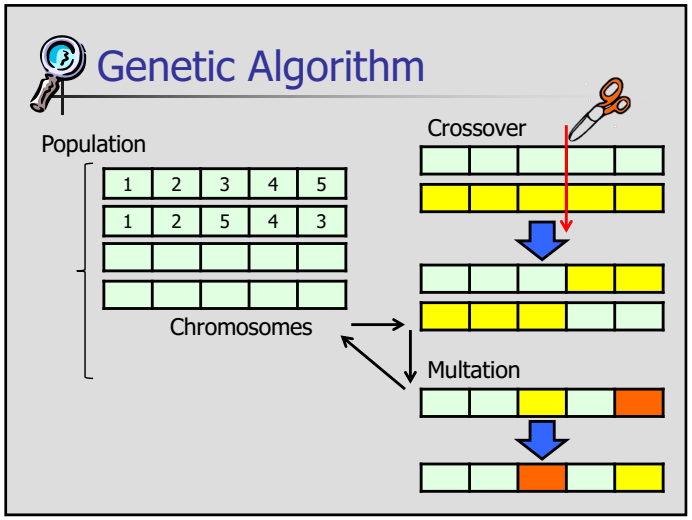
Hierarchical structures | Grouped nodes | Edge contraction

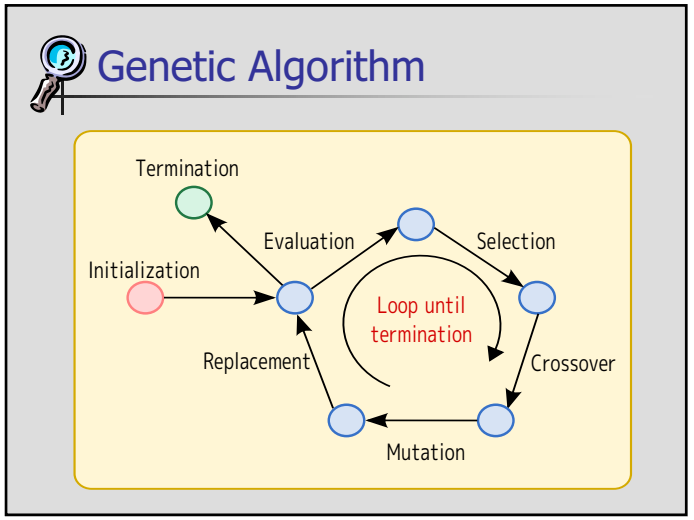


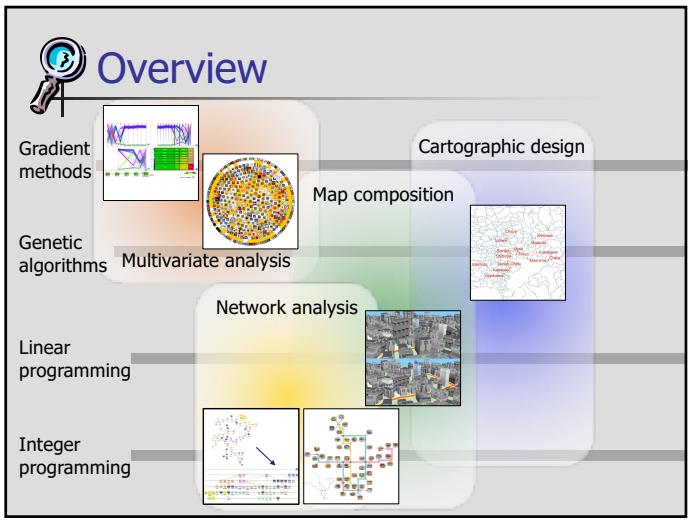
Optimized layout large-sized P2P network

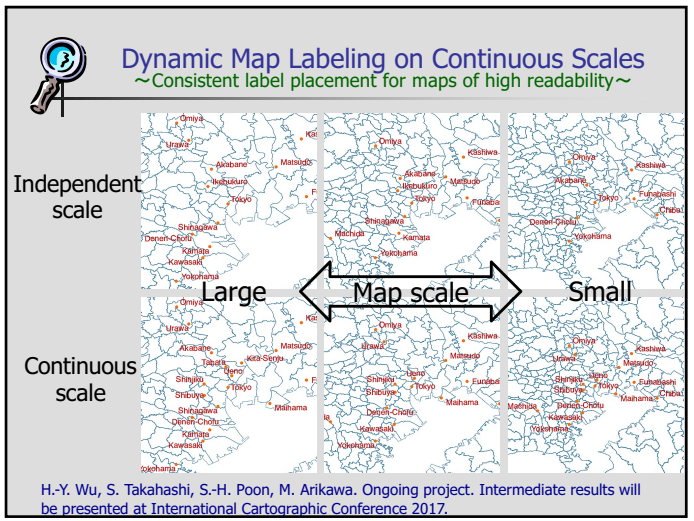
Overview




Genetic Algorithm
Population
1 2 3 4 5
1 2 5 4 3
Chromosomes
Crossover
Multation


Genetic Algorithm
Termination
Evaluation
Selection
Initialization
Loop until termination
Replacement
Crossover
Mutation


Overview
Gradient methods
Genetic algorithms
Multivariate analysis
Map composition
Cartographic design
Network analysis
Linear programming
Integer programming


Dynamic Map Labeling on Continuous Scales
~Consistent label placement for maps of high readability~
Independent scale
Continuous scale
Large
Map scale
Small
H.-Y. Wu, S. Takahashi, S.-H. Poon, M. Arikawa. Ongoing project. Intermediate results will be presented at International Cartographic Conference 2017.

デジタルマップの普及

- 異なるスケール(縮尺)による地図表示

109

ラベル配置の問題点

- スケールの変化にラベル出現消滅する

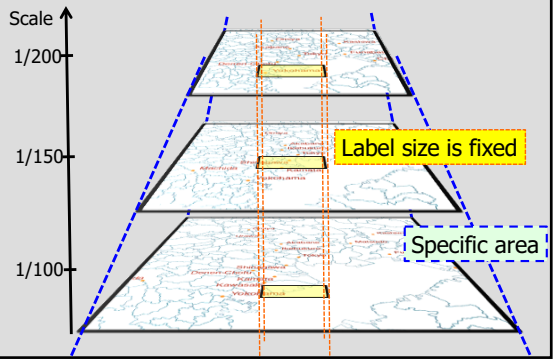
110

Objectives

- Optimize label placement on the map
- Retain the consistency in labeling over the map scale

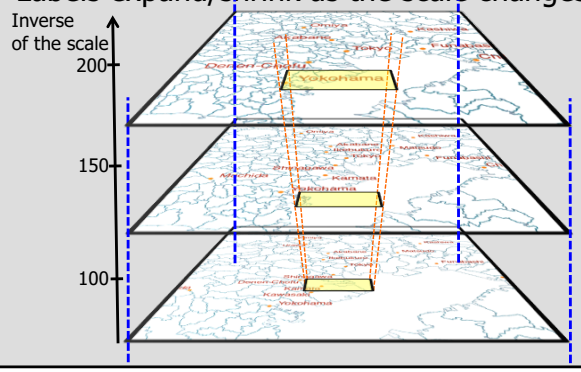
Scale-Aware Label Placement

- Specific area shrinks as the scale reduces



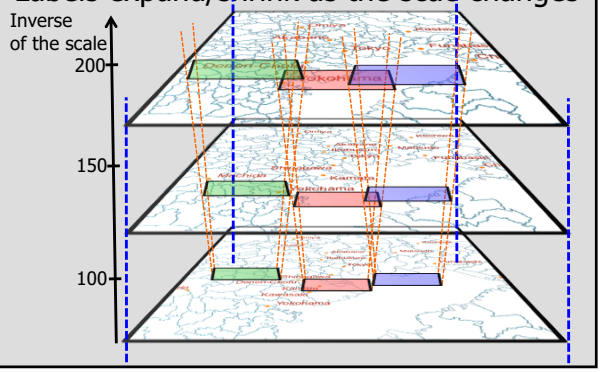
Scale-Aware Label Placement

- Labels expand/shrink as the scale changes



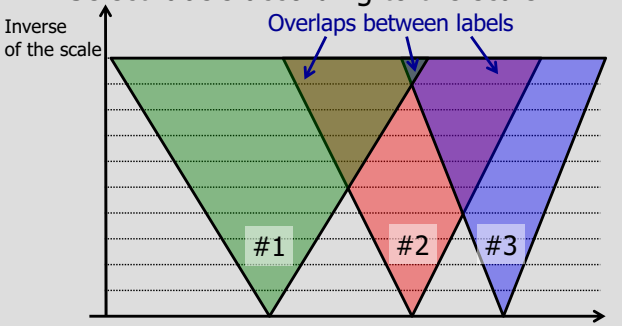
Scale-Aware Label Placement

- Labels expand/shrink as the scae changes



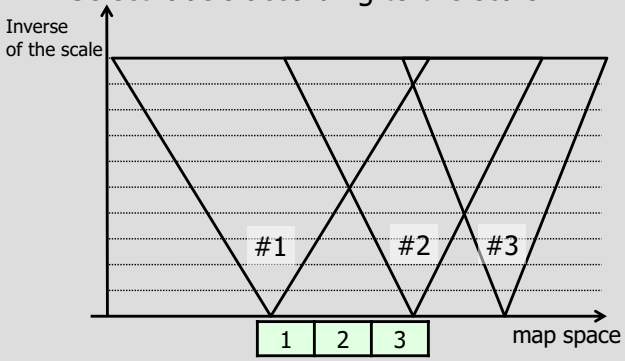
Scale-Aware Label Placement

- Select labels according to the scale



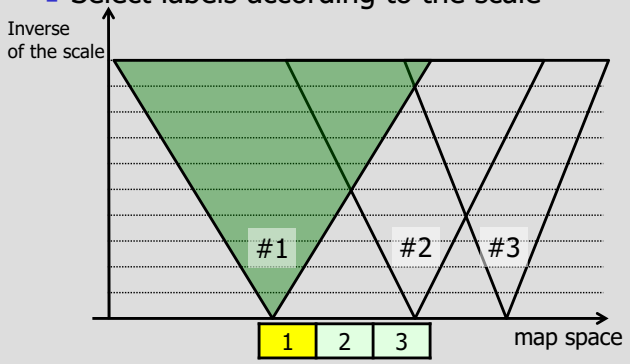
Scale-Aware Label Placement

- Select labels according to the scale



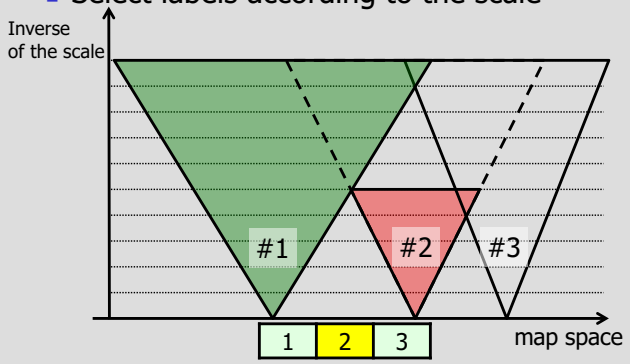
Scale-Aware Label Placement

- Select labels according to the scale



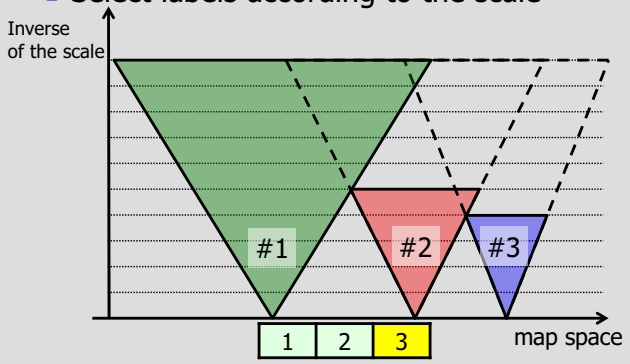
Scale-Aware Label Placement

- Select labels according to the scale



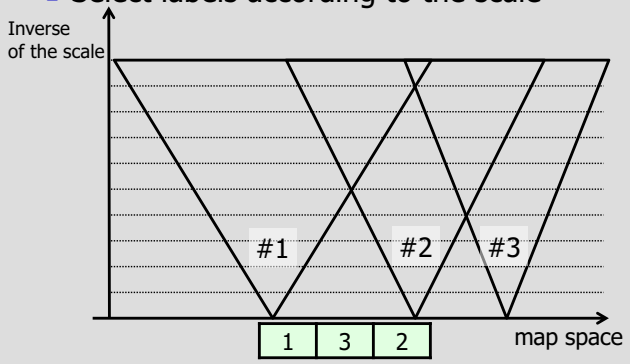
Scale-Aware Label Placement

- Select labels according to the scale



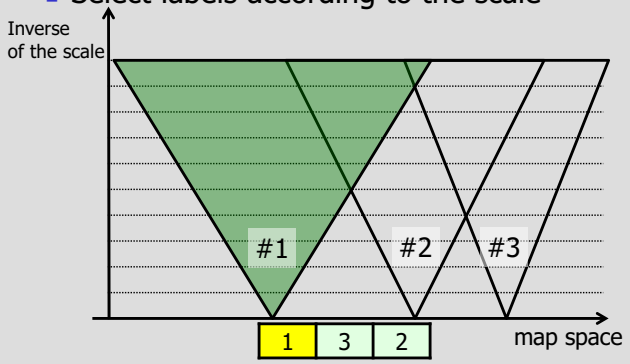
Scale-Aware Label Placement

- Select labels according to the scale



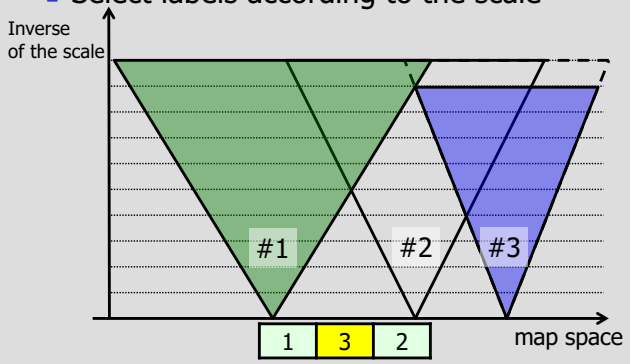
Scale-Aware Label Placement

- Select labels according to the scale



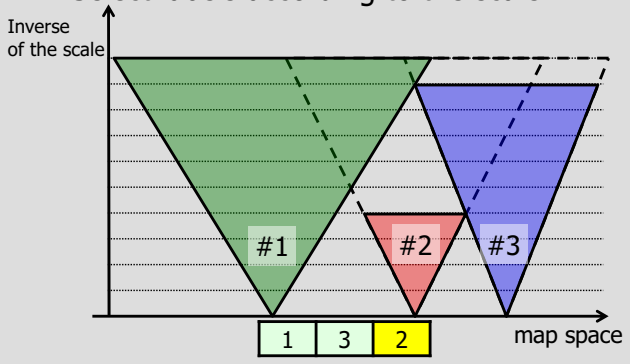
Scale-Aware Label Placement

- Select labels according to the scale



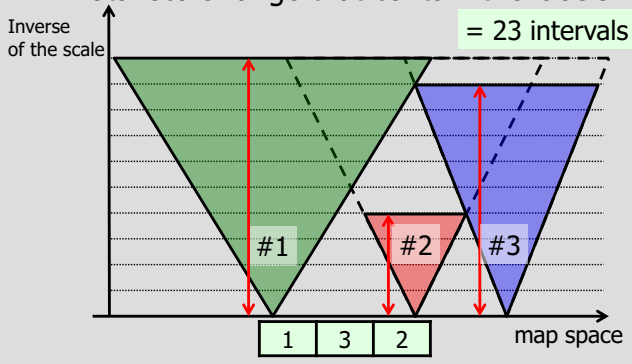
Scale-Aware Label Placement

- Select labels according to the scale



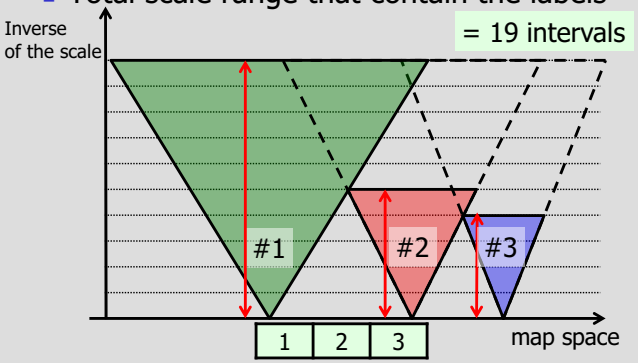
Active Range

- Total scale range that contain the labels



Active Range

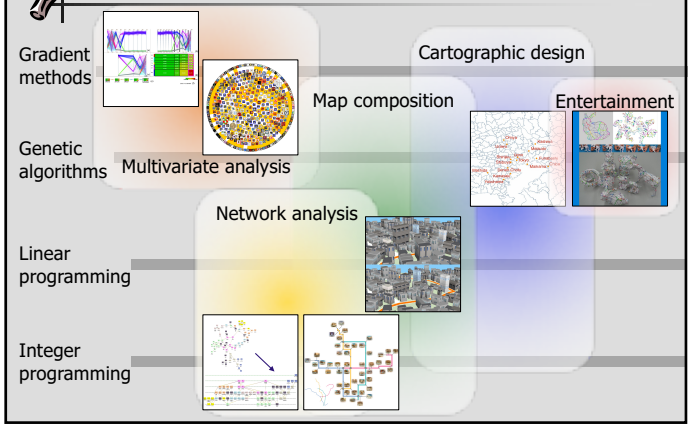
- Total scale range that contain the labels



Demonstration

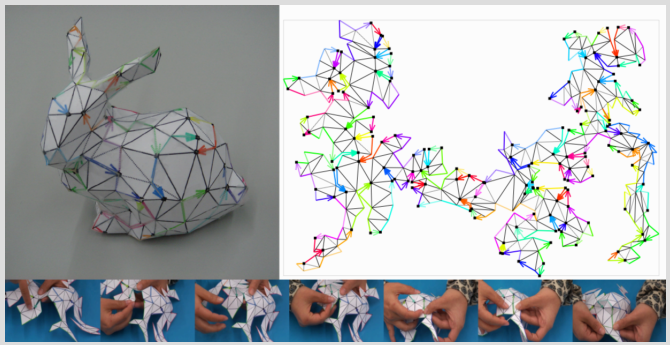
Overview
(Tokyo, Japan)

Overview



Topological Surgery for Mesh Unfolding

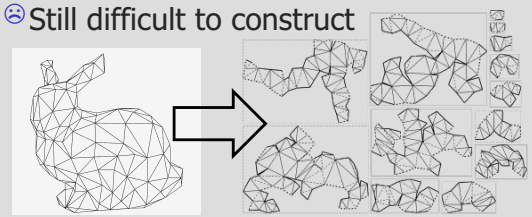
~Papercraft Construction from a Single Patch~



S. Takahashi, H.-Y. Wu, S. H. Saw, C.-C. Lin, H.-C. Yen. Optimized Topological Surgery for Unfolding 3D Meshes, Computer Graphics Forum, 30(7), 2077-2086, 2011.

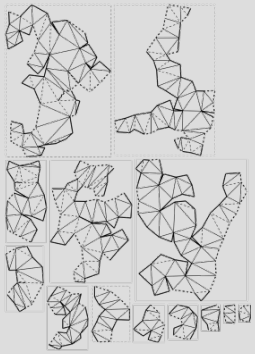
Papercraft Models

- ☺ Can retrieve 3D physical shapes
- ☺ For preparing the miniatures of 3D scenes
- ☺ Fun for both children and adults
- ☹ Still difficult to construct



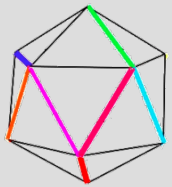
Why Difficult?

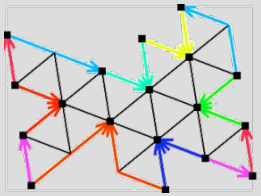
- Practical issues
  - Large number of unfolded patches, including small fragments
  - Troubles in finding correspondence between a pair of cut edges



Key Ideas

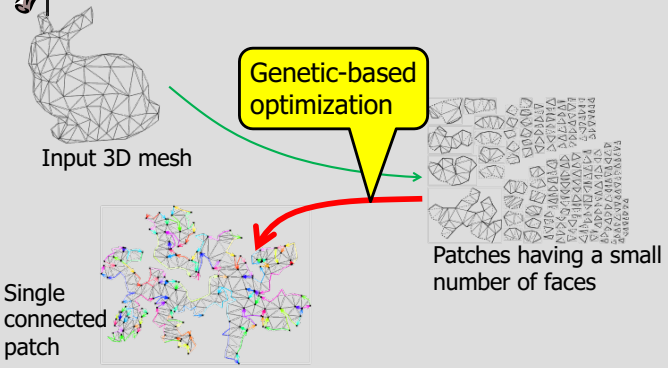
- Employ the topological surgery to encode the boundary edges of the unfolded patch
- Genetic-based approach to unfolding a 3D mesh into a single connected patch





Papercraft Construction Example

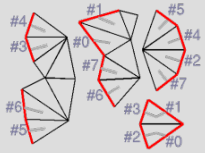
Processing Pipeline



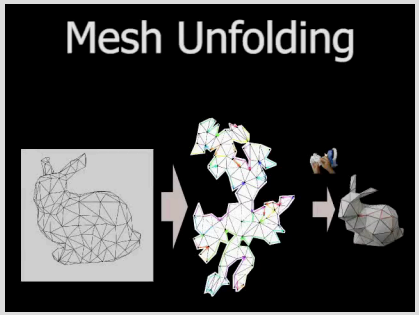
Stitching Unfolded Patches

- Encode the order of edges to be stitched together as a chromosome
- Apply a genetic algorithm with improved crossover and mutation operations

#4	#2	#5	#3	#6	#7	#1	#0



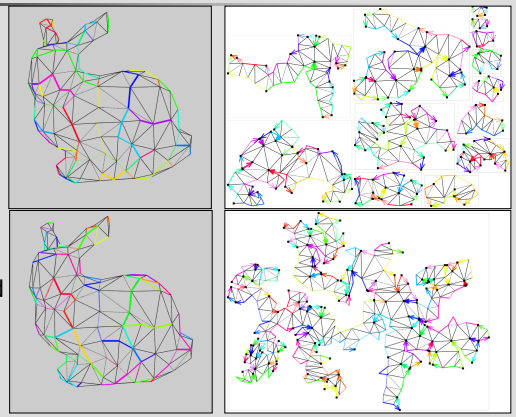
Mesh Unfolding Process



Results (Bunny; 348 faces)

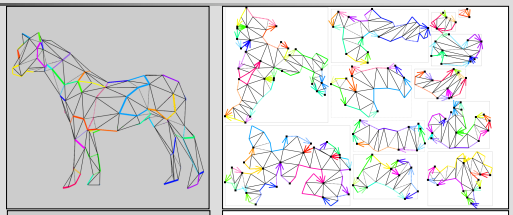
Conventional MST-based approach
#{patches}=13

Our proposed approach
#{patches}=1

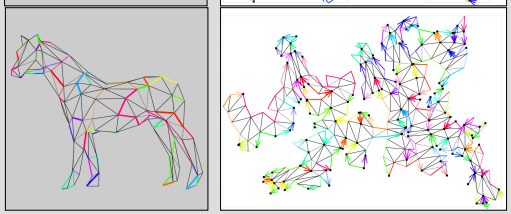


Results (Horse; 312 faces)

Conventional MST-based approach
#{patches}=12

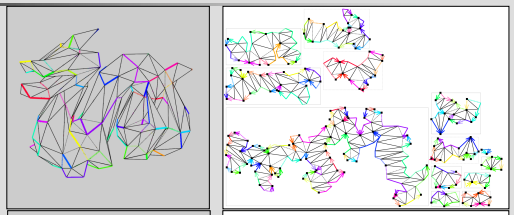


Our proposed approach
#{patches}=1

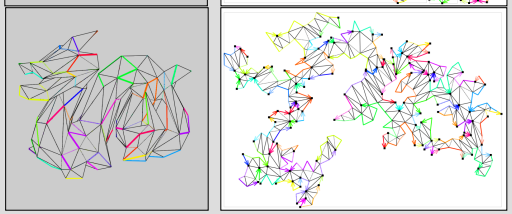


Results (Dragon; 344 faces)

Conventional MST-based approach
#{patches}=13

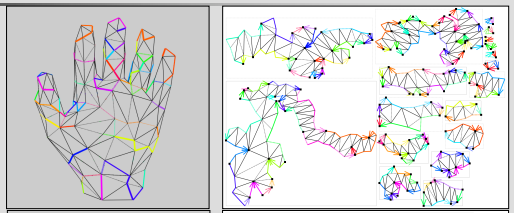


Our proposed approach
#{patches}=1

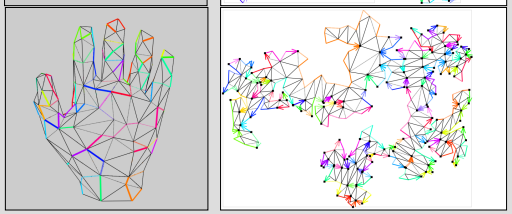


Results (Hand; 336 faces)

Conventional MST-based approach
#{patches}=18

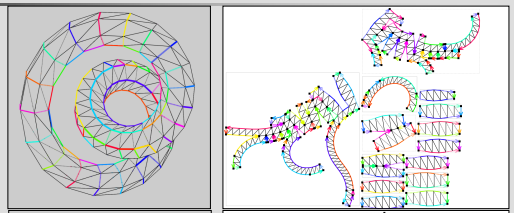


Our proposed approach
#{patches}=1

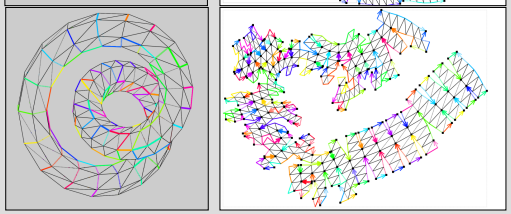


Results (Knot; 480 faces)

Conventional MST-based approach
#{patches}=14



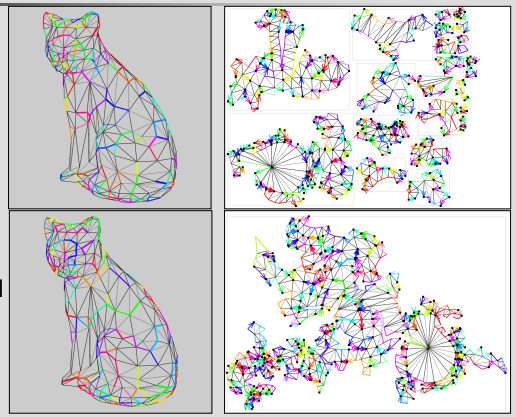
Our proposed approach
#{patches}=1



Results (Cat; 702 faces)

Conventional MST-based approach
#{patches}=28

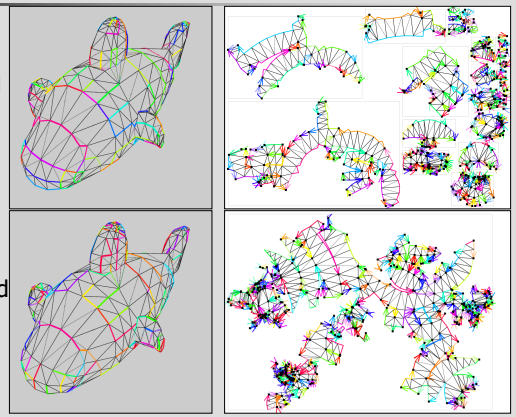
Our proposed approach
#{patches}=1



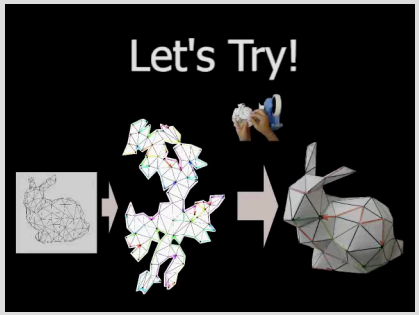
Results (Fish; 950 faces)

Conventional MST-based approach
#{patches}=31

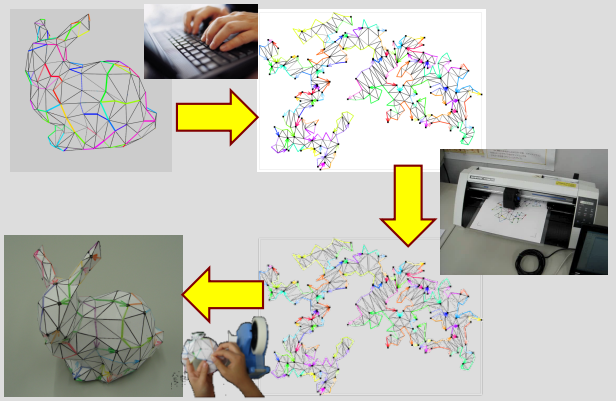
Our proposed approach
#{patches}=1



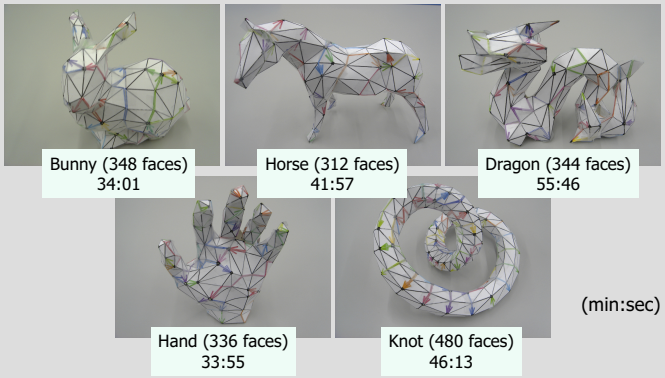
Papercraft Construction



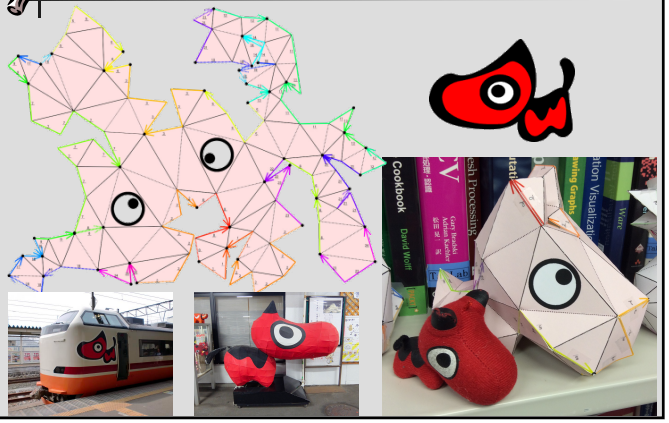
Papercraft Construction



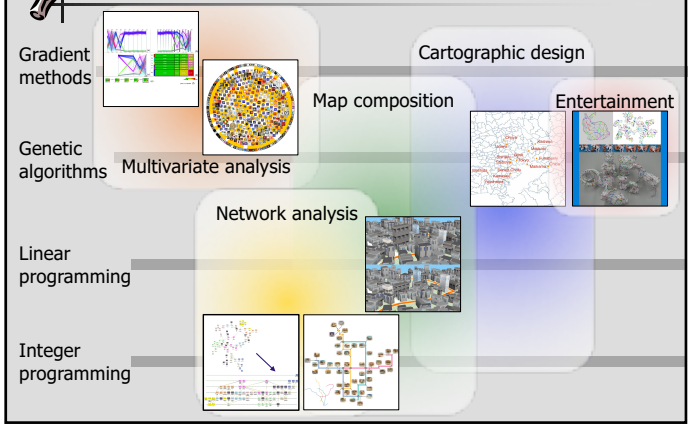
Results



あかべぇを作ろう

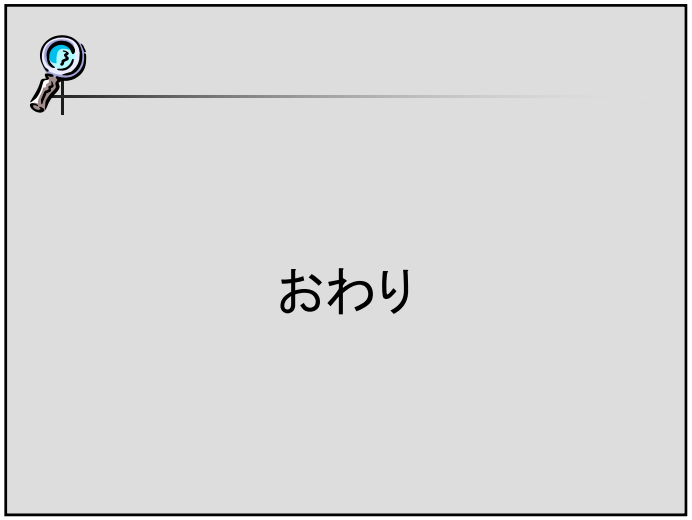


Overview



おわりに

- 情報可視化における幅広い技術課題を統一的に最適化問題として定式化
  - 多変量データ視覚解析
  - ネットワークデータ可視化
  - 地図の図式表現と設計
  - おまけ: 娯楽
- 個々の問題をどのようにモデル化するかが解決への糸口に


おわり