Identifying Divergent Building Structures Using Fuzzy Clustering of Isovist Features

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MOTIVATION

"Alternative routes in complex environments"

Indoor Navigation

- Assistance in hospitals, airports, fairs, ...
- Mobile robots (smart city, ambient assistant living)
- Non-player character in computer games

Alternative routes

- What is an alternative route? How to find them?
- Is there a quality of alternative routes?
- How to get preferably diverse routes?

Leaving the application level

- Similarity or distance metrics of geospatial trajectories
- In particular regarding indoor scenarios, i.e. floor plans of buildings





TWO CONTRIBUTIONS

Basically

A background service for LBS

Maps

- Insights about building structure using plain floorplan
- Classification of indoor areas and surroundings (entrance areas, corridors, halls, streets)
- Clustering of isovist features via archetypal analysis

Routes

- Analyze effect of isovist features on archetypal routes
- Alternative routes based on perception





ISOVISTS

 A_x area

 P_{χ} real-surface perimeter (amount of visible obstacle surface)

 Q_x occlusivity (length of occluding radial boundary)

 $M_{2,x}$ variance (distribution of radials length)

 $M_{3,x}$ skewness (distribution's asymmetry)

 N_{χ} circularity (isoperimetric quotient)



Benedikt M (1979) To take hold of space: isovist and isovist fields. Environment and Planning B 6(1): 47-65

ARCHETYPAL ANALYSIS

Archetypal analysis (AA)

- Focusses on extrema, prototypes, originals, pure types → "preferably diverse"
- Approximates dataset's convex hull in feature space using k points (=archetypes)

Error decreases with different number of k archetypes

- k = 1 average
- k = n each observation is an archetype

Use screeplot and "elbow criterion" to identify suitable value of k



Cutler A, Breiman L (1994) Archetypal analysis. Technometrics 36(4): 338-347

ARCHETYPAL ANALYSIS



Input

- Map with r rows and c columns
- $N \times m$ matrix X
- N = r × c observations
- m = 6 attributes $\{A_x, P_x, Q_x, M_{2,x}, M_{3,x}, N_x\}$





Parallel coordinates plot

- Isovist features on abscissae, corresponding values on ordinate
- Each gray line represents a walkable pixel
- k = 3, i.e. three archetypes



Interpretation

- Good lookout with extremely high area A_x
- Moderate real-surface P_x, high occlusivity Q_x and high variance M_{2,x} indicate diverse line of sight
- Rather lower values
- Particularly low variance (M_{2,x}) indicates regular shape
- Moderate area A_x, plenty of walls to be seen (high P_x), and low occlusivity Q_x suggest uniform and simplistic structure



Colored pixels with threshold lpha > 0.5

- Open space, quite compact
- Restricted and regular view, rooms or smaller halls
- Very restricted in two directions, very wide otherwise, like narrow halls or streets around the building
- White area as an interesting effect



k = 4



Deep view into entrances (very high occlusivity Q_x , i.e. the length of the occluding radial boundary)

k = 5



Spectator would see much area while having a wall behind the back

RESULTS – IDENTIFYING ALTERNATIVE ROUTES

Setup

- 400 routes representing the observations
- Each observation has got 5 × 6 = 30 attributes (min, max, mean, median, variance)
- Scree plot suggests k = 3



Feld S, Werner M, Schönfeld M, Hasler S (2015)Archetypes of Alternative Routes in Buildings.In: 6th International Conference on Indoor Positioning and Indoor Navigation (IPIN 2015), pp. 1-10



RESULTS – IDENTIFYING ALTERNATIVE ROUTES

Interpretation

- Traversing consistently through patio having several variations at start/end
- Very straight through streets or long and narrow halls
- Variations (shortcuts or detours) are located in rather narrow spaces
- Variable, following variations of rooms and doors
- \rightarrow Archetypes based on impression, not only their geographic location

k = 3, threshold $\alpha > 0.8$



RESULTS – FEATURES VS. (NO) TIME



CONCLUSION AND FUTURE WORK

Conclusion

- Fuzzy clustering using computed perception of space
- Different environment areas and alternative routes based on visibility properties

Future Work

- Focus on measurements along the routes using stacked isovist visualization and visual analytics
- Incorporate different route creation algorithms and random start/goals







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