Introduction

• The facility layout problem studies the relationship between function and form. However, to make it easier to solve, constraints are placed on the shape, making it difficult to study this relationship.

• What can we learn about function and form if we remove the shape constraints?

• Three questions and three experiments to answer them:
  1. How does facility shape affect optimal solutions?
  2. What shapes result from different flow matrices?
  3. How does the objective function affect the facility’s shape?

What is Space Syntax?

Set of techniques for representation, quantification and interpretation of spatial configuration in buildings [1].

Basic approach to a Space Syntax analysis [2]:
1. Define spatial units – locations/departments.
2. Define spatial relations among those units – adjacency.
3. Construct a graph of the facility in terms of each spatial relation.
4. Define spatial metrics to be computed from the spatial relation graphs – depth.
5. Compute the values of the spatial metrics.

Experiment 1

How does changing facility shape affect optimal solutions?

Spatial Metric
Depth
Number of locations between locations i and j

Operational Metric
Total travel distance

Step 1
Find depth minimizing shapes

Step 2
Solve QAP for those shapes

Step 3
Compare with rectangular facilities

Experiment 2

How do operational patterns affect facility shapes?

Spatial Metrics
- Depth (D)
- Radius-1 Neighbors (R1)
- Radius-2 Neighbors (R2)

Operational Metrics
- Flow Volume (FV)
- Number of Flows (NF)

Facility Shapes
- Rectangular
- Depth-minimizing
- Free-form

Flow Matrices
- Global flow
- Localized flow
- Highly-structured flow

Step 1
Calculate spatial metrics for all facility shapes

Step 2
Find best solutions for all facility shapes

Step 3
Calculate spatial metrics for facilities, operational metrics for departments

Step 4
Generate metric maps

Results

- a. Optimal value: 37
  Value: 35
- b. Optimal value: 51
  Value: 46
- c. Optimal value: 17
  Value: 13
- d. Optimal value: 68
  Value: 56
- e. Optimal value: 34
  Value: 30

Conclusions

• A framework for analyzing the relationship between function and form in facility layout design using principles of Space Syntax was proposed.

• There is a significant relationship between objective function value and shape.

• There are important correlations between the operational characteristics of a department and the spatial characteristics of its final location within the facility.

• Different structures in the flow matrix (different operational patterns) manifest themselves spatially in different ideal facility shapes.

References
