“Referring Expressions in Location Based Services: The Case of the ‘Opposite’ Relation ”

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Contents

- Location Based Services
- What is a Referring Expression?
- Qualitative spatial relations
- Visibility modelling
- Definition of Opposite
- Opposite for a Line
- Opposite for a Space (region)

Location Based Services

- An information service accessed from a mobile application which can use location/context automatically in filtering/presenting data
- Typically LBS uses proximity in Euclidean or network space to filter items
- The introduction of LiDAR data has allowed visibility modelling to be added as a filter in LBS research
- The user interfaces for LBS applications tend to rely on GUIs, however this distracts the user from their surroundings
- Alternatives:
  - Augmented reality;
  - Speech interfaces... which allows for hands-free, and eyes-free interactions.

Referring Expression

- In natural language, a descriptive term which is used to disambiguate an object from others in a scene
- This can use descriptors such as the shape, size, colour, and position.
- Position can reference the surrounding features in a scene
- In LBS, natural language can be used:
  - Generation of phrases to direct the user's attention
  - Parsing of phrases to determine which object is being interrogated

"The green one"
"The lowest one"

Spatial relations

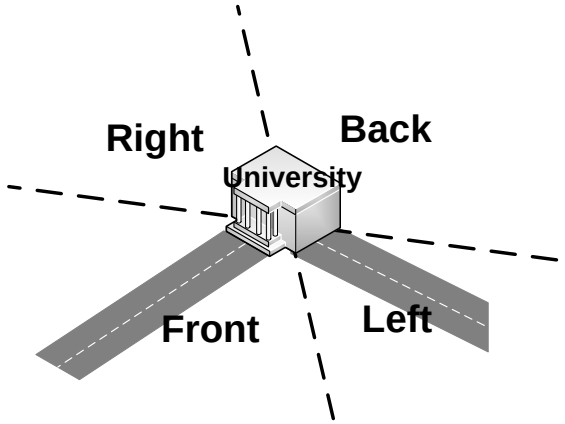
- Referring expressions use qualitative spatial relations

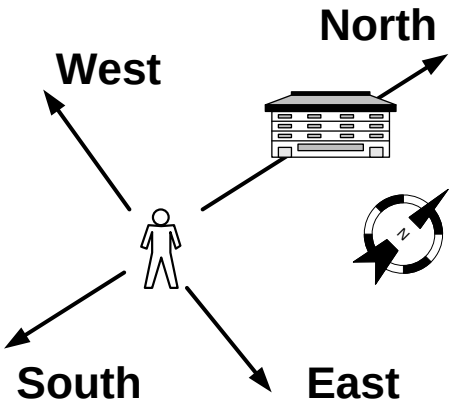
- Topological relations:
  - They don't change with the point of view
  - They represent survey knowledge
    - E.g., "a house inside a park"

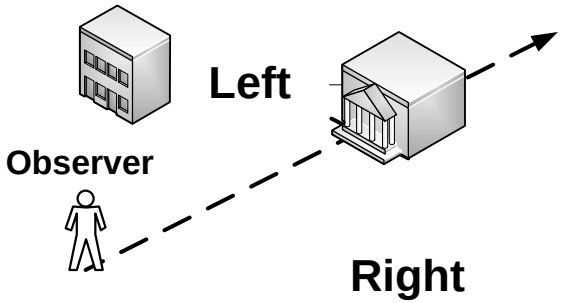
- Projective relations:
  - They change with the point of view
  - They represent relative knowledge
    - E.g., "in front of the swings", "left of the house"

Frames of reference

- Retz-Schmidt's classification:
  - Intrinsic
  - Extrinsic
  - Deictic

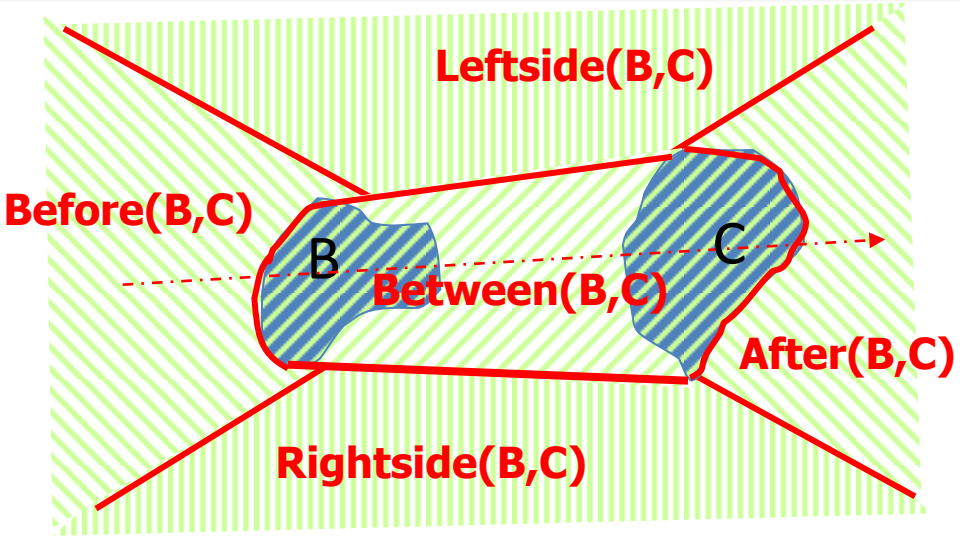






Projective relations

- Ternary relations
  - Primary object A
  - Reference objects B, C

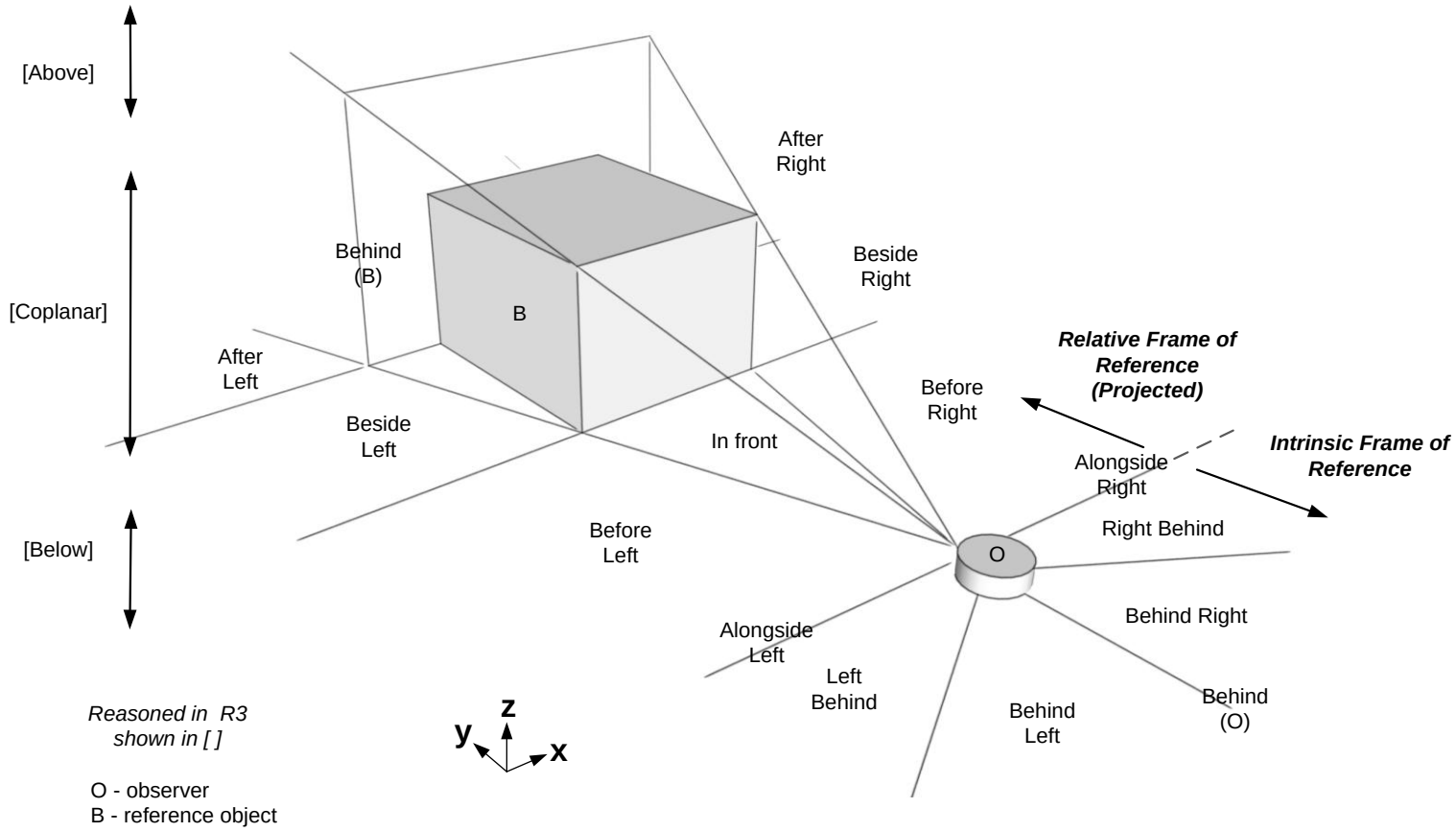


- 5-intersection

	A ∩ Leftside(B,C)	
A ∩ Before(B,C)	A ∩ Between(B,C)	A ∩ After(B,C)
	A ∩ Rightside(B,C)	

Combined model of space

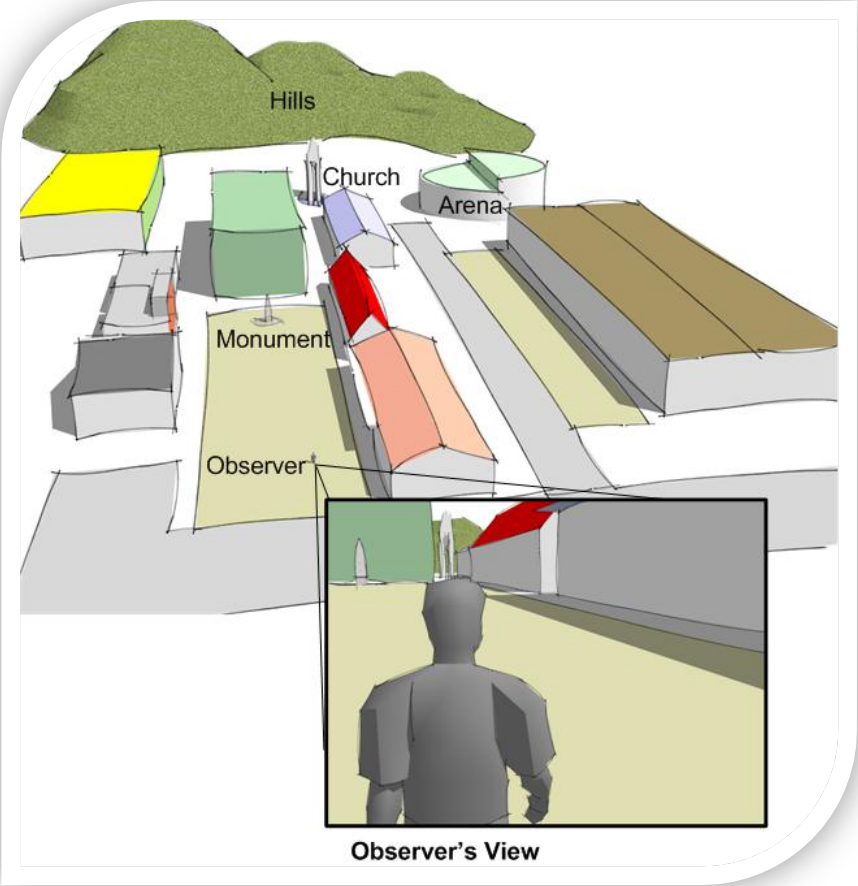
The first reference object is the observer
3D extension (above, coplanar, below)
It uses two different frames of reference



Vista Space

- LBS user - egocentric view of the world

- What is near me?
- What is that over there?
- Is that [landmark]?
- Can I see [landmark]?
- What does the building look like?
- What's the building opposite the park?



Currently use proximity filtering (near me), networks (how to get to)

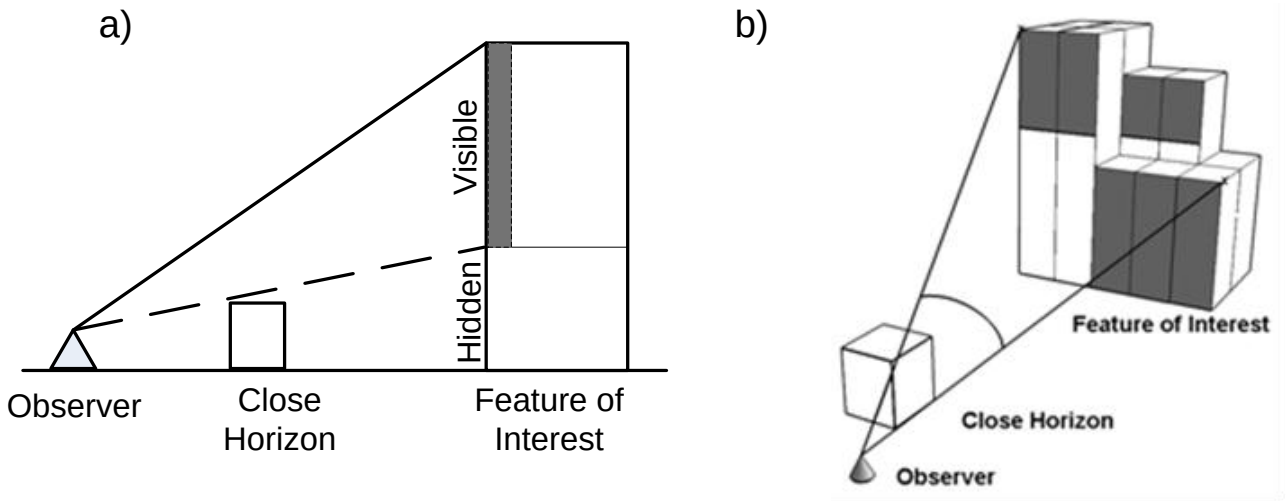
MISSING?
Ability to filter a database of features of interest based on their **visibility**

NEED?
A model of the urban space that includes the surface objects (trees, buildings) as well as topography (hills)

LiDAR sourced Digital Surface Model

Visibility modeling

From DSM, 3D isovists, visual exposure models, etc. can build visibility models



the case of opposite...

- **Opposite** is defined as:

  "set over against something that is at the other end or side of an intervening **line** or **space**"
  (Merriam-Webster Dictionary)

  = Inter-related visibility of 3 visual entities

  =Need to be able to see the items in the relationship for it to make sense...

  Two cases:

  intervening line (one dimensional)

  intervening region (two-dimensional)

Opposite - 1D common feature

- **“the library is opposite the park”**

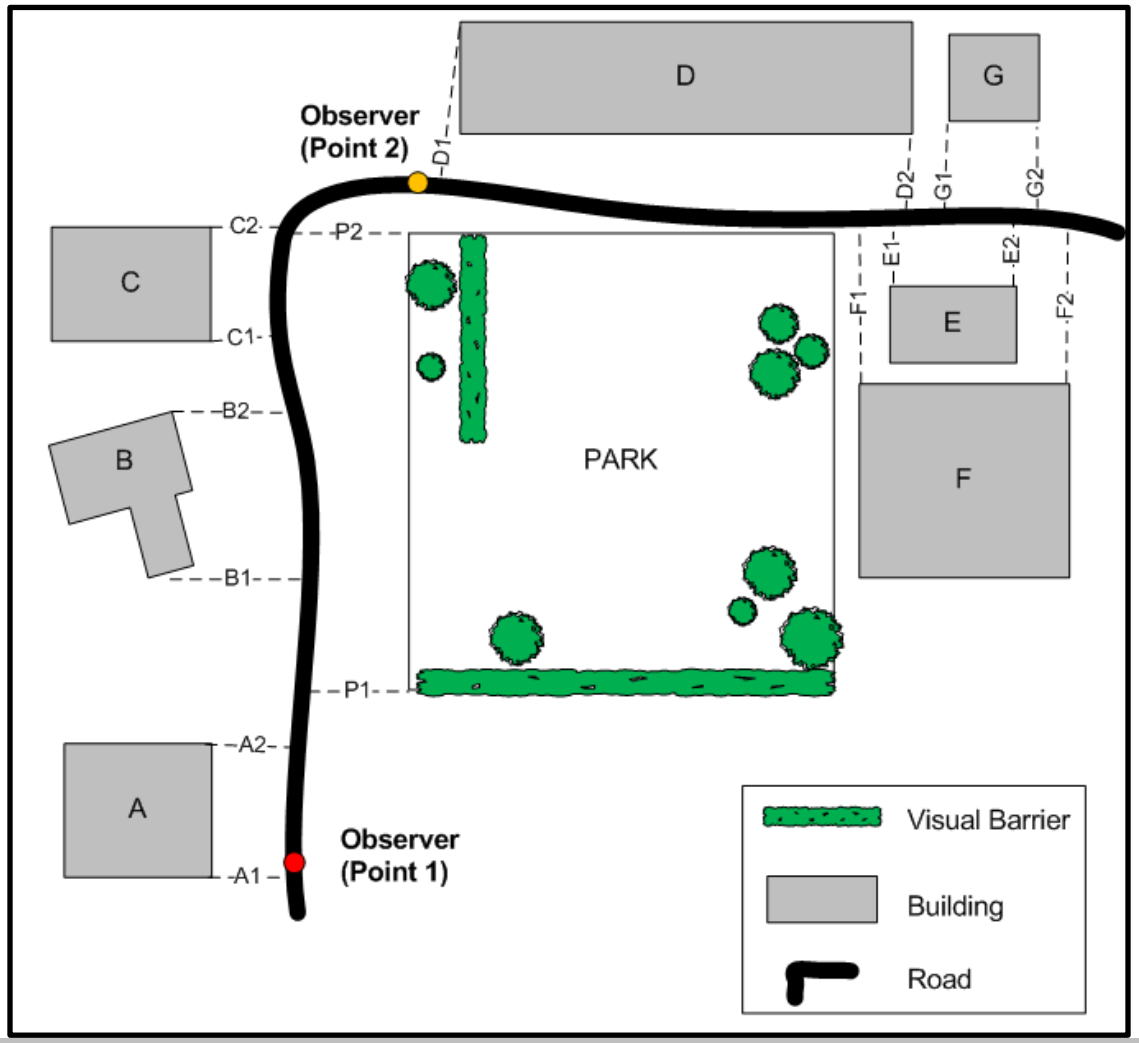
can be broken down into

“the library is *left of the road”*

and

“the park is right of the road

However this does not signify that the two objects are “opposite” each other unless both are perceived to occur at similar positions along the road.

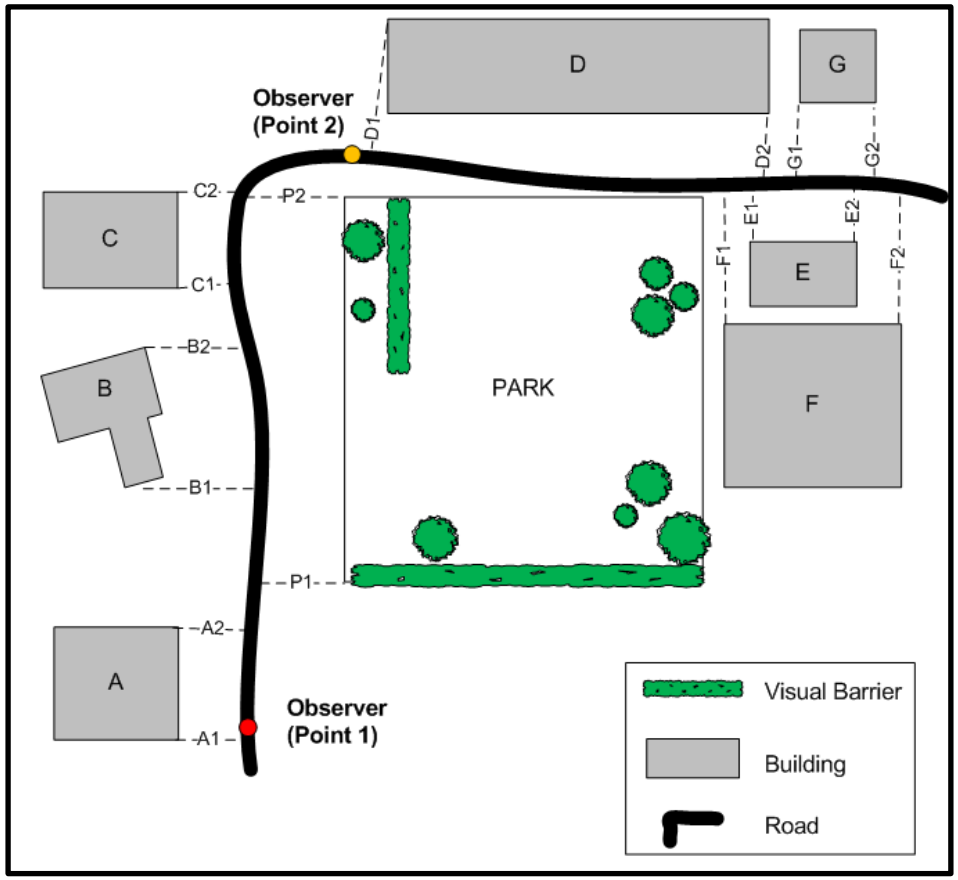


When the observer at Point 1 faces Building C, it is valid to report that both Buildings C and B are “opposite” the park. Here the term “with reference to the road” is left out but inferred, and the phrase is equivalent to “Building C is on the other side of the road from the park”.

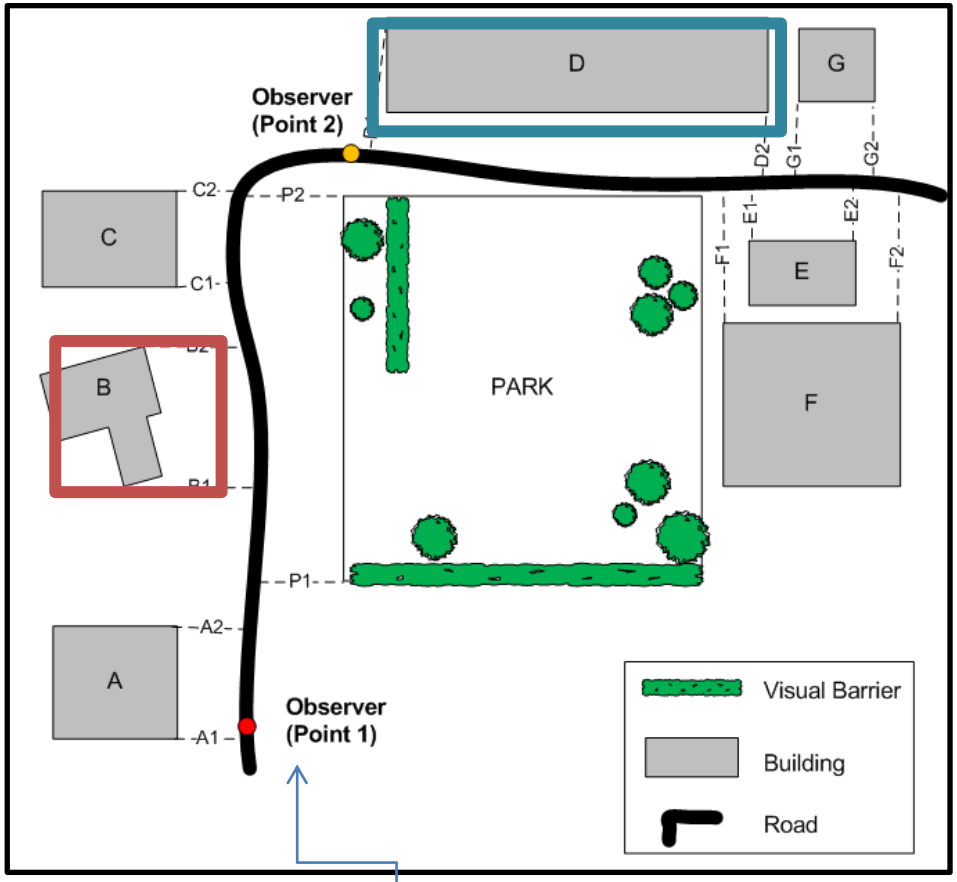
However it would not be appropriate to define Building A as “opposite the park”, as the two features do not share a similar location along the linear road feature, yet the phrase “opposite side of the road” is still true

To satisfy the "opposite" condition the following must apply:

- the observer must be able to view both entities from a single point (e.g. C and Park)
- the entities must occur at overlapping sections of the linear entity (e.g. C1-C2 and P1-P2)
- the observer must also be able to view the common linear entity in the overlap region (e.g. road)
- the entities must occupy *beside left/right space when viewed from the overlapping region*



Linear common feature



Need to see the common space between objects for the definition to make sense… so from Point 1 D and the Park are not considered opposite, as the user cannot see that D is on the other side of the road…

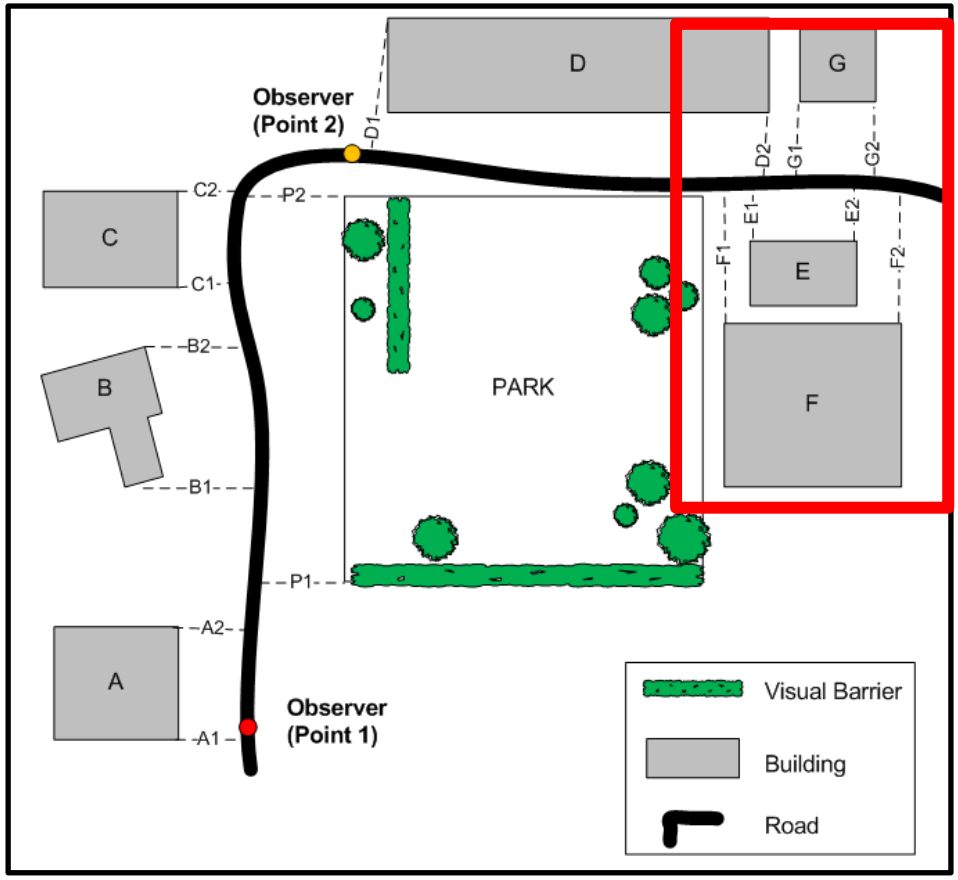
From Observer at Point 1

Entity	Visible	Overlap	View Common Overlap	Beside Left/Right when viewed from overlapping region	Result
A	True	False	True	True	False
B	True	True	True	True	True
C	True	True	True	True	True
D	True	True	False	True	False
E	False	False	False	False	False
F	False	False	False	False	False
G	False	False	False	True	False

Which Opposite object should be selected to be used in a referring expression?

- Saliency is a measure of the prominence of a feature in the neighbourhood, and there are methods to quantify such distinctiveness

- Typically factors including visual appearance and semantic interest are considered by comparing items in the neighbourhood to establish the most easily recognisable and rare features.



Which is the best feature to use in a description?

eg. 1)
(For an Observer at Point 2)

G is opposite E
G is opposite F

If F is a church then may be better choice

e.g. 2)
Not useful to describe your house as opposite a tree if the street is filled
with trees...

Most suitable entity = f(V,S,N,D,O)

where:

V – visibility (degree of visibility of all items from a single observation point)

S – saliency (prominent, minimise confusability (ie rare))

N – number of items between (measure of separation by entity count)

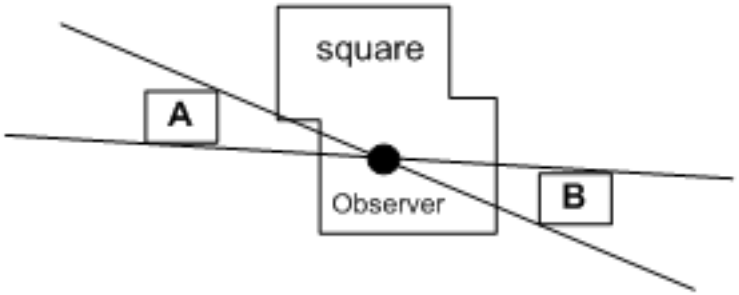
D – distance apart (close items preferred)

O – degree of overlap

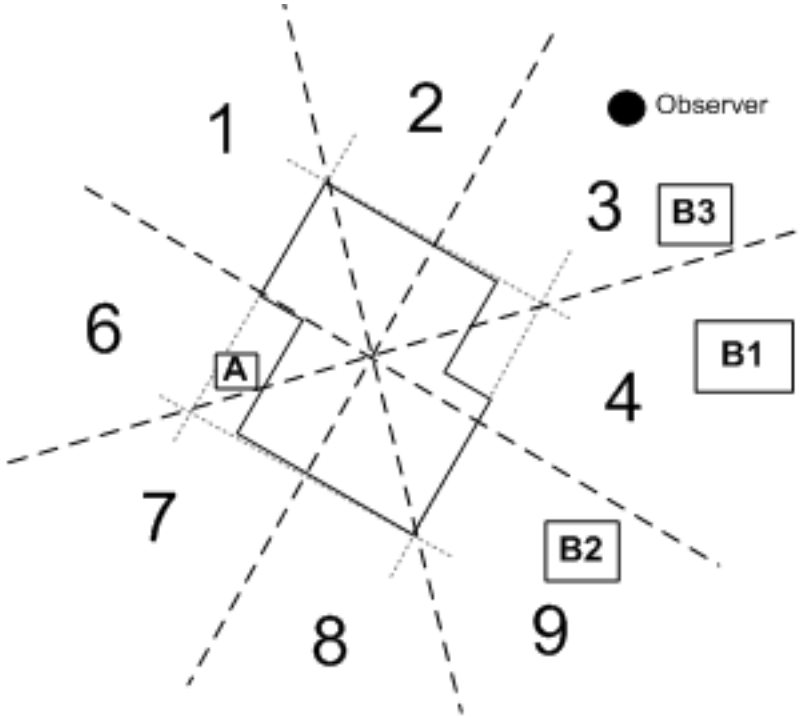
Opposite – 2D common space

- Observer in common space
- Observer outside common space

Common Region



(i)



(ii)

(i) Observer in common space - in front / behind relationship

(ii) Observer outside common space – Orientate Min Bounding Box around region – divided into 8 zones – sum must add to 10 to be opposite.. neighbouring zones also included (so A and B1 are opposite... Plus B2,B3)

Additional Considerations

- At greater viewing distances, and for smaller items, it may be harder for the observer to judge when two entities share an opposite relation and it may be necessary to restrict the inclusion of the term.

Thanks!