Task-Oriented Information Value Measurement based on Space-Time Prisms

Yingjie Hu[1], Krzysztof Janowicz[1], Yuqi Chen[2]

[1] Department of Geography
[2] Department of Statistics and Applied Probability
University of California Santa Barbara

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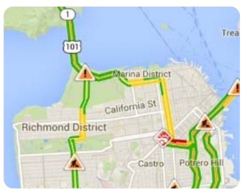
Information plays an important role in our everyday tasks

Meetings

Restaurants



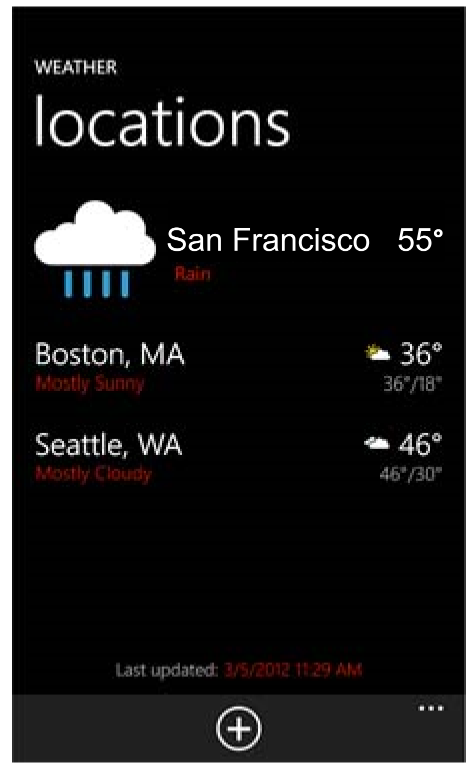
Traffic

Flights

Weather

...

The role of information from a cognitive perspective



Mobile devices: major tools for retrieving and displaying information

When small screens encounter big data

Can we prioritize information?

A framework that integrates information value theory with space-time prisms

Information item 1

Information item 2

Information item 3

…

Information item n

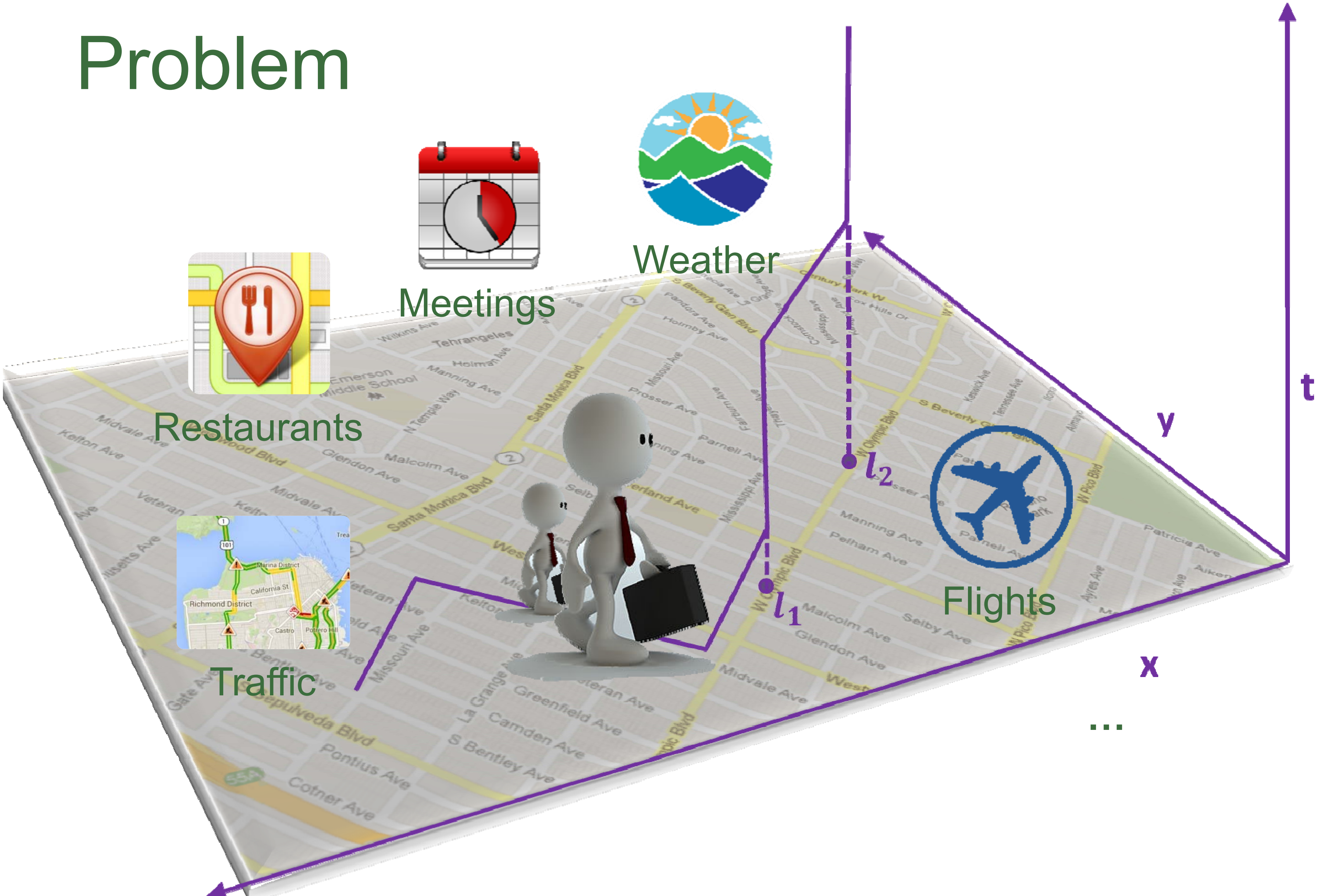
High priority

Low priority

Problem

- An individual has *m* tasks to complete
  - Each task has its spatiotemporal properties: Locations, preferred arrival time, duration, waiting
- The mobile device has access to *n* information items
  - Each information item indicates certain spatiotemporal change of the current status
- Goal: measure the values of the *n* information items with regard to the *m* tasks

Problem



Information Value Theory (IVT)

- Originally proposed in economics and artificial intelligence
- Measures the value of information with regard to decisions

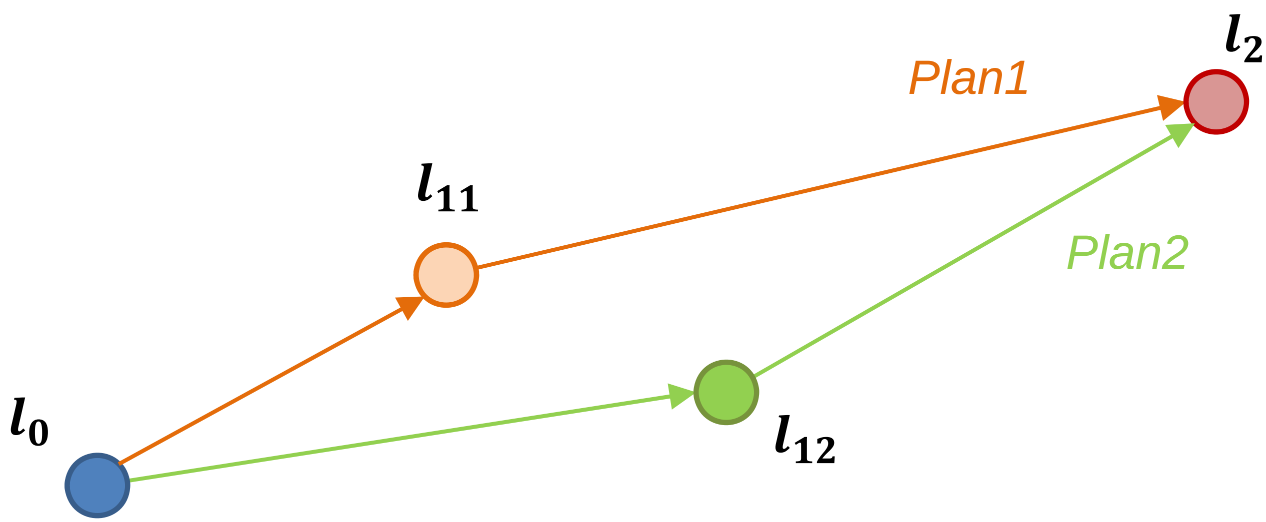
$$V(I) = U(d') - U(d)$$

- Applied to investment analysis and clinical assessment
  - Focusing on monetary value
  - Ignoring spatiotemporal properties

Integrating IVT with time geography

$$V(I) = U(d') - U(d)$$

- Decision maker: the individual
- Decision *d*: to make a *plan* to complete the *m* tasks



Integrating IVT with time geography

$$V(I) = U(d') - U(d)$$

- Space-time prisms for representing the spatiotemporal properties of tasks

- *U*: extending the utility function from space-time accessibility studies
  - *Burns (1979), Miller (1999)*
  - *Ettema and Timmermans (2007)*

Integrating IVT with time geography

$$V(I) = U(d') - U(d)$$

- Utility function in accessibility study (*Burns, 1979, Miller 1999*):

$$U = a^{\alpha} D^{\beta} \exp(-\lambda T)$$

- An extension to include early and late arrivals (*Ettema and Timmermans, 2007*)

$$U = a^{\alpha} D^{\beta} \exp(-\lambda T) \exp(-\gamma_1 SDE) \exp(-\gamma_2 SDL)$$

Integrating IVT with time geography

$$V(I) = U(d') - U(d)$$

- A *plan* as completing a sequence of tasks:

$$plan = \{\boldsymbol{S}_1, \boldsymbol{S}_2, \boldsymbol{S}_3, \ldots \boldsymbol{S}_m\}$$

- The utility of a *plan*:

$$U(plan) = \sum_{j=1}^{m} U(\boldsymbol{S}_j) * exp(-\lambda \sum_{j=1}^{m} T_{(j-1),j})$$

Integrating IVT with time geography

$$V(I) = U(d') - U(d)$$

- For each task, one location is selected from the candidate locations:

$$\boldsymbol{S}_{jk} = < l_{jk}, a_{jk}, PAT_{jk}, AAT_{jk}, D_{jk}, D'_{jk} >$$

- The utility of completing one task:

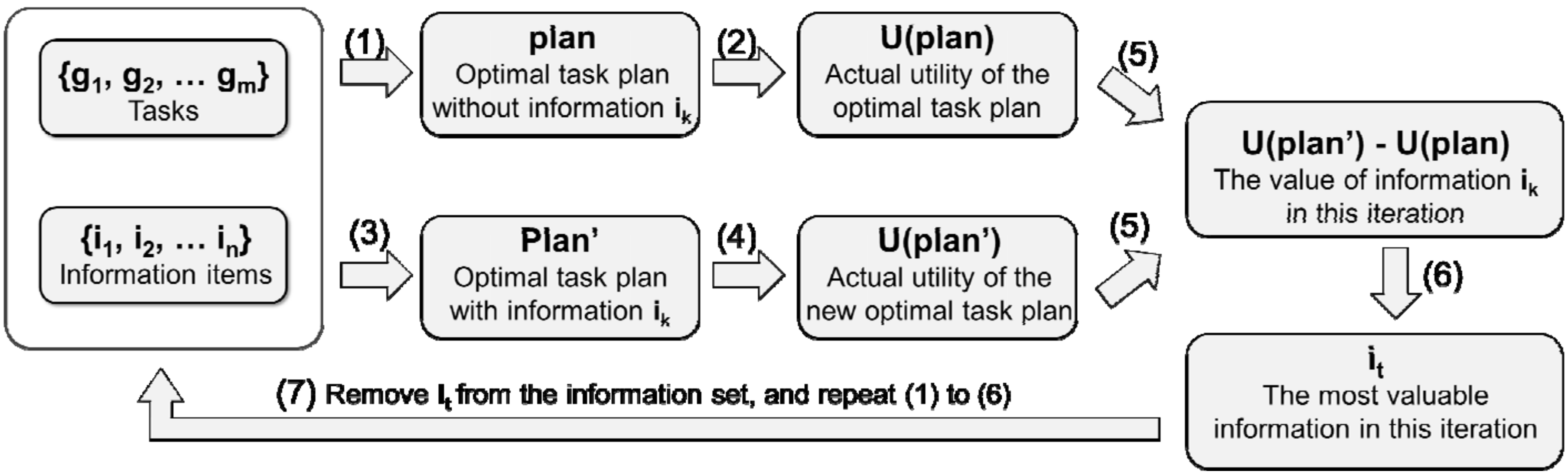
$$U(\boldsymbol{S}_{jk}) = a_{jk}^{\alpha}\, f(D_{jk}, D'_{jk}) h(PAT_{jk}, AAT_{jk})$$

- Measuring the value of information:

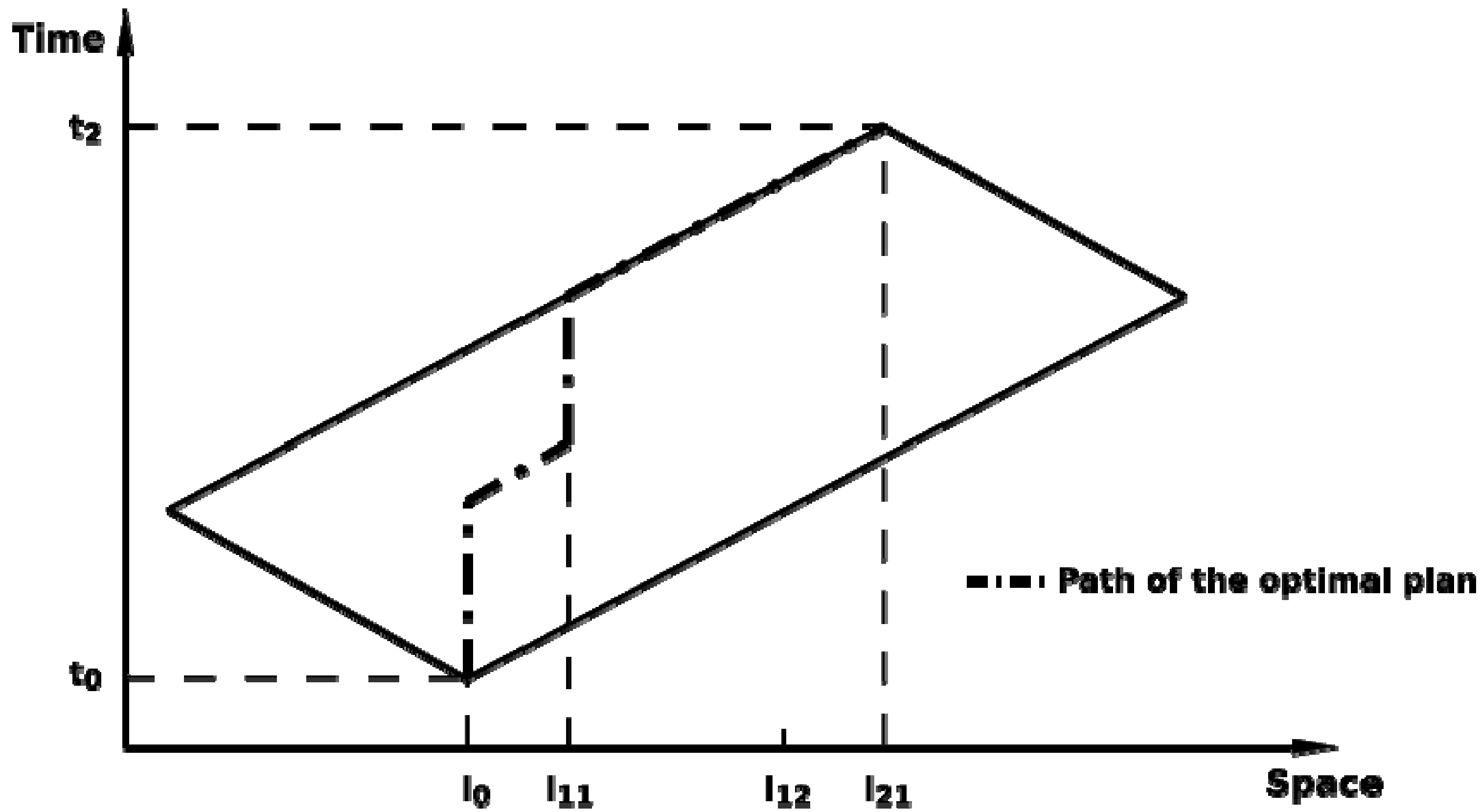
$$V(I) = U(plan') - U(plan)$$

Integrating IVT with time geography

- A workflow for ranking the priorities of multiple information items

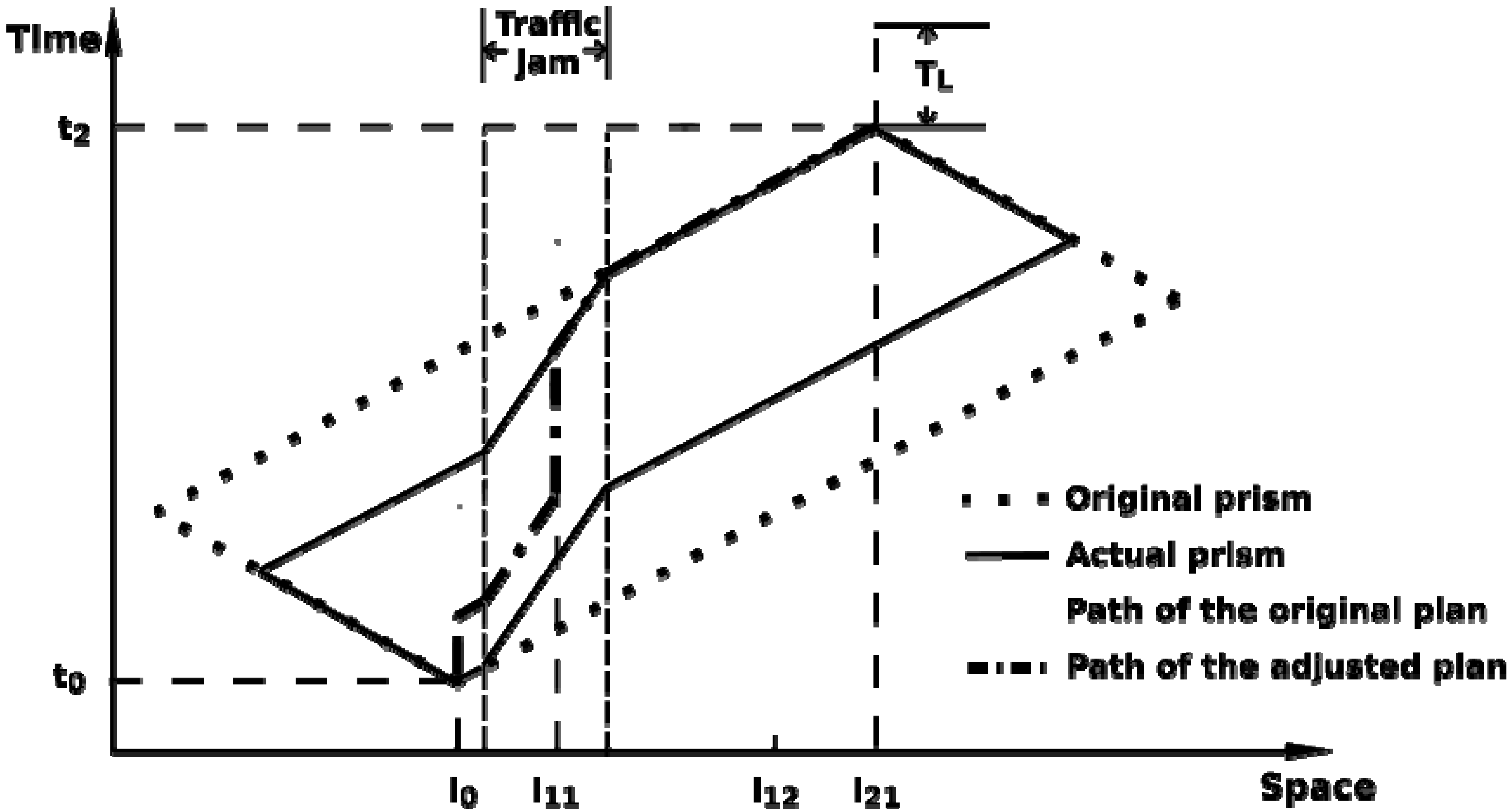


A simplified example



A simplified example

- Traffic congestion information $I_{traffic}$



A simulation based on a road network

- Tasks: 1) breakfast; 2) workshop
- Information: $I_{traffic}, I_{loc}, I_{temp}, I_{wait}$

A simulation based on a road network

$$I_{loc} > I_{traffic} > I_{wait} > I_{temp}$$

Conclusions and future work

- A theoretical framework for measuring the value of information
- An integration between space-time prisms and information value theory
- Prioritized information display on small-screen mobile devices
- Further evaluations based on human participant experiments are necessary

Questions and suggestions?

Yingjie Hu

PhD Candidate
Email: yingjiehu@umail.ucsb.edu
Web: http://geog.ucsb.edu/~hu

$$U(\boldsymbol{S}_{jk}) = a_{jk}^{\alpha} f(D_{jk}, D'_{jk}) h(PAT_{jk}, AAT_{jk})$$

$$f(D_{jk}, D'_{jk}) = \left[\min\left\{\frac{D'_{jk}}{D_{jk}}, 1\right\}\right]^{\beta}$$

$$h(PAT_{jk}, AAT_{jk}) = \exp(-\gamma_1(PAT_{jk} - AAT_{jk})^{+}) \exp(-\gamma_2(AAT_{jk} - PAT_{jk})^{+})$$