

Applying Covariance Structure Analysis to Reveal Relationships Between Agent Capability and Map Characteristics in RoboCup Rescue Simulation

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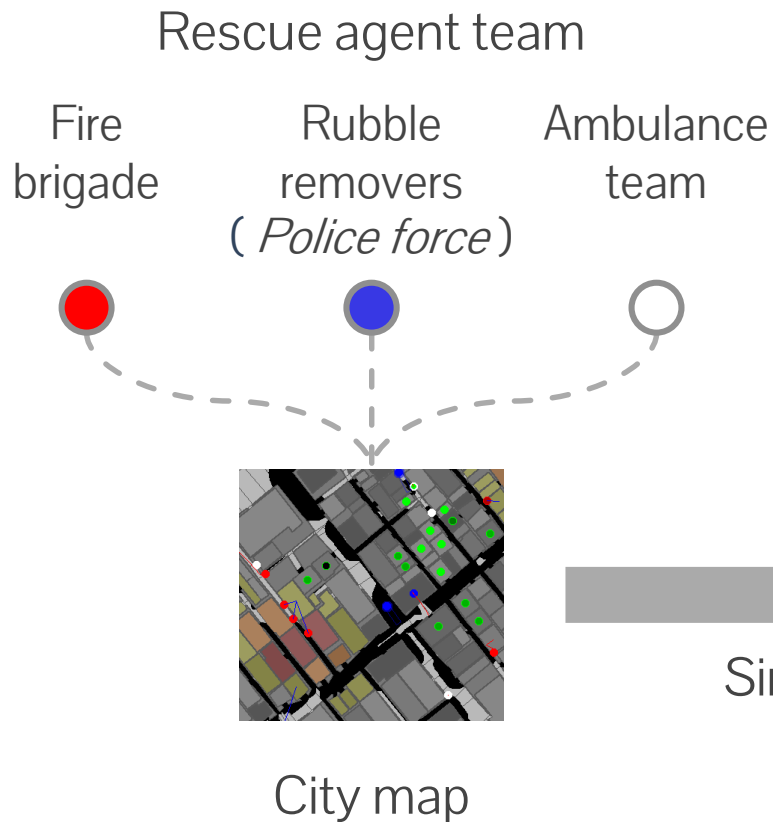
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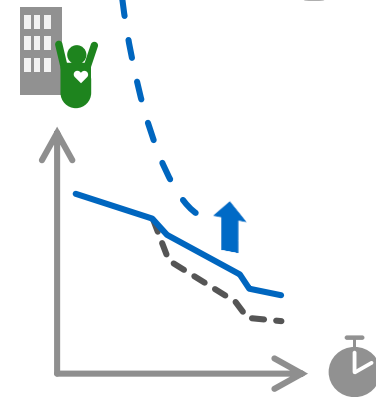
² Aichi University

Disaster relief simulation

RoboCup Rescue Simulation



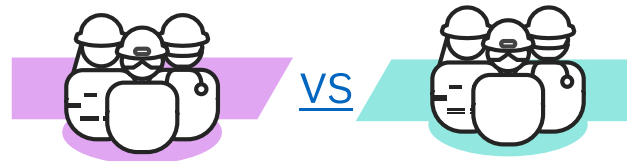
The team is attempting to maintain the city value (score) by rescue operations.



Problem in evaluating agent teams' capability

Which one is the better agent team ?

Rescue agent teams

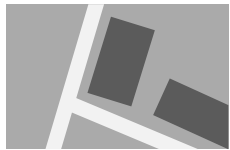


Target area maps

Team A

Team B

Better team



Map 1

45 1st

35 2nd



Team A



Map 2

20 2nd

30 1st



Team B

It is necessary to clarify the relationship between environment and teams' capability

Objective of this study

Compare the capabilities of rescue agent teams with the common indices

Define the **environmental factors** from the maps' characteristics

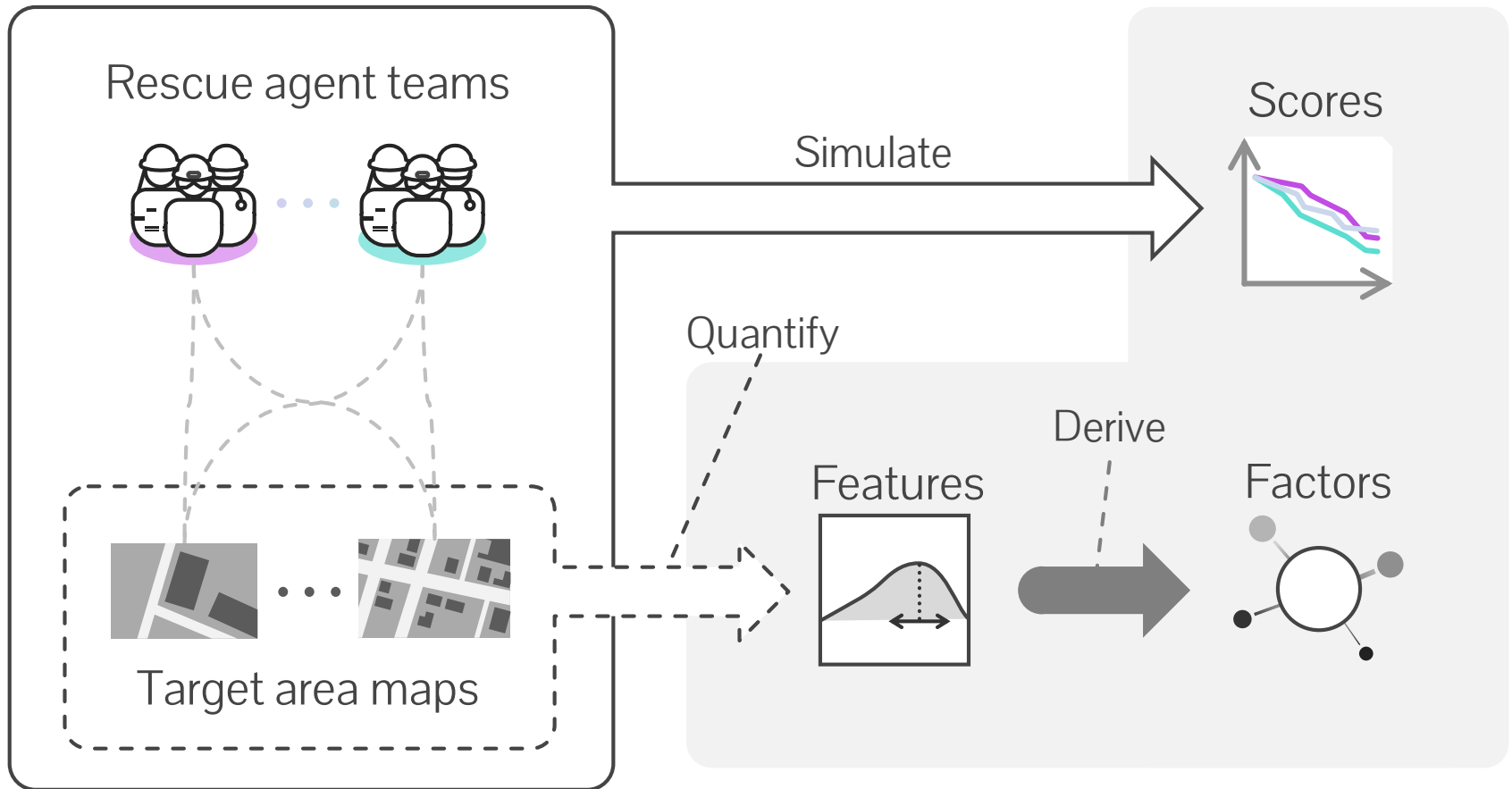


Analyze the effects of the **environmental factors** on the **score**



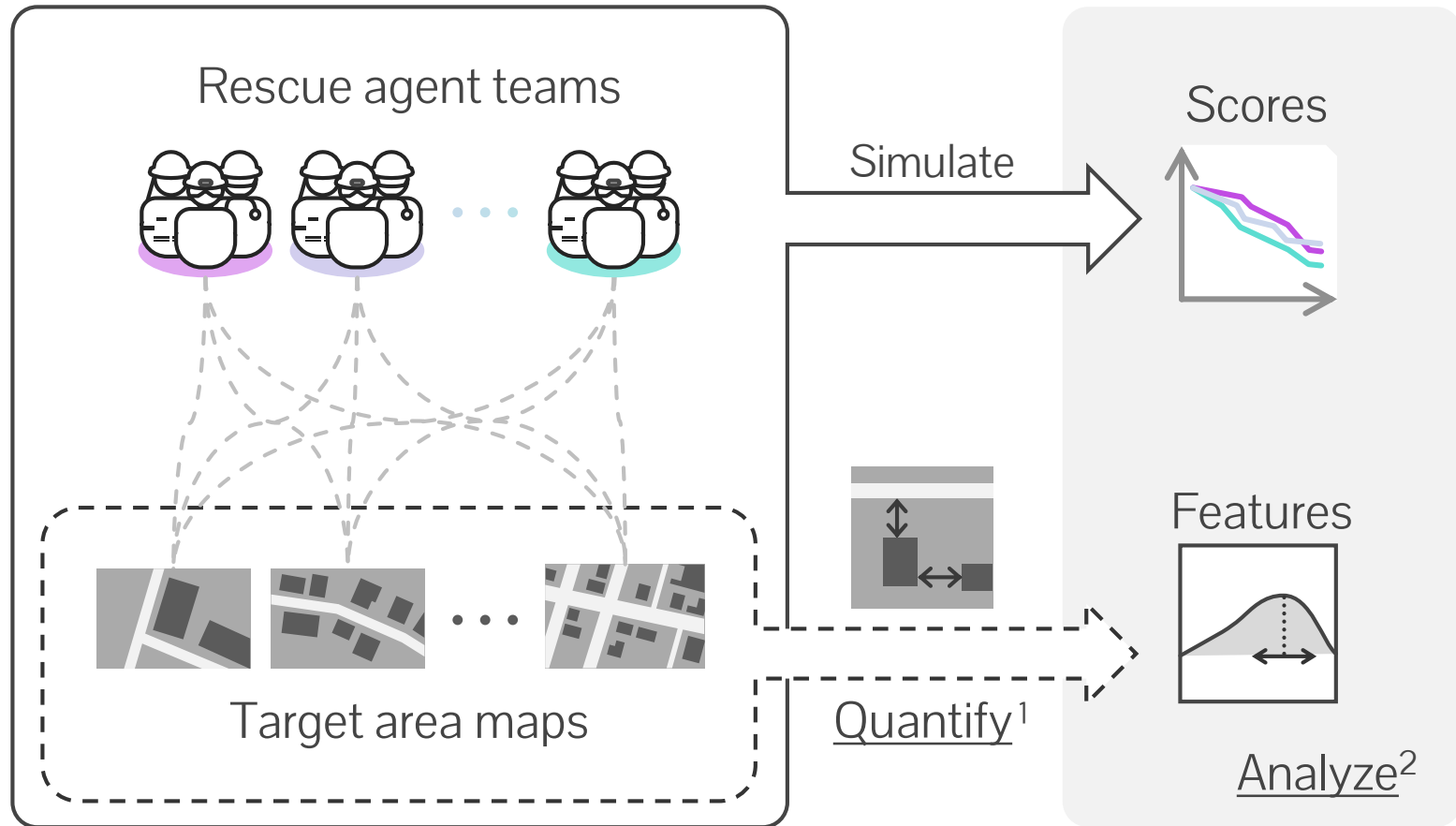
Be able to compare the capabilities of the agent teams using common environmental factors

Analysis flow of this study



Analyze using some of the statistical models

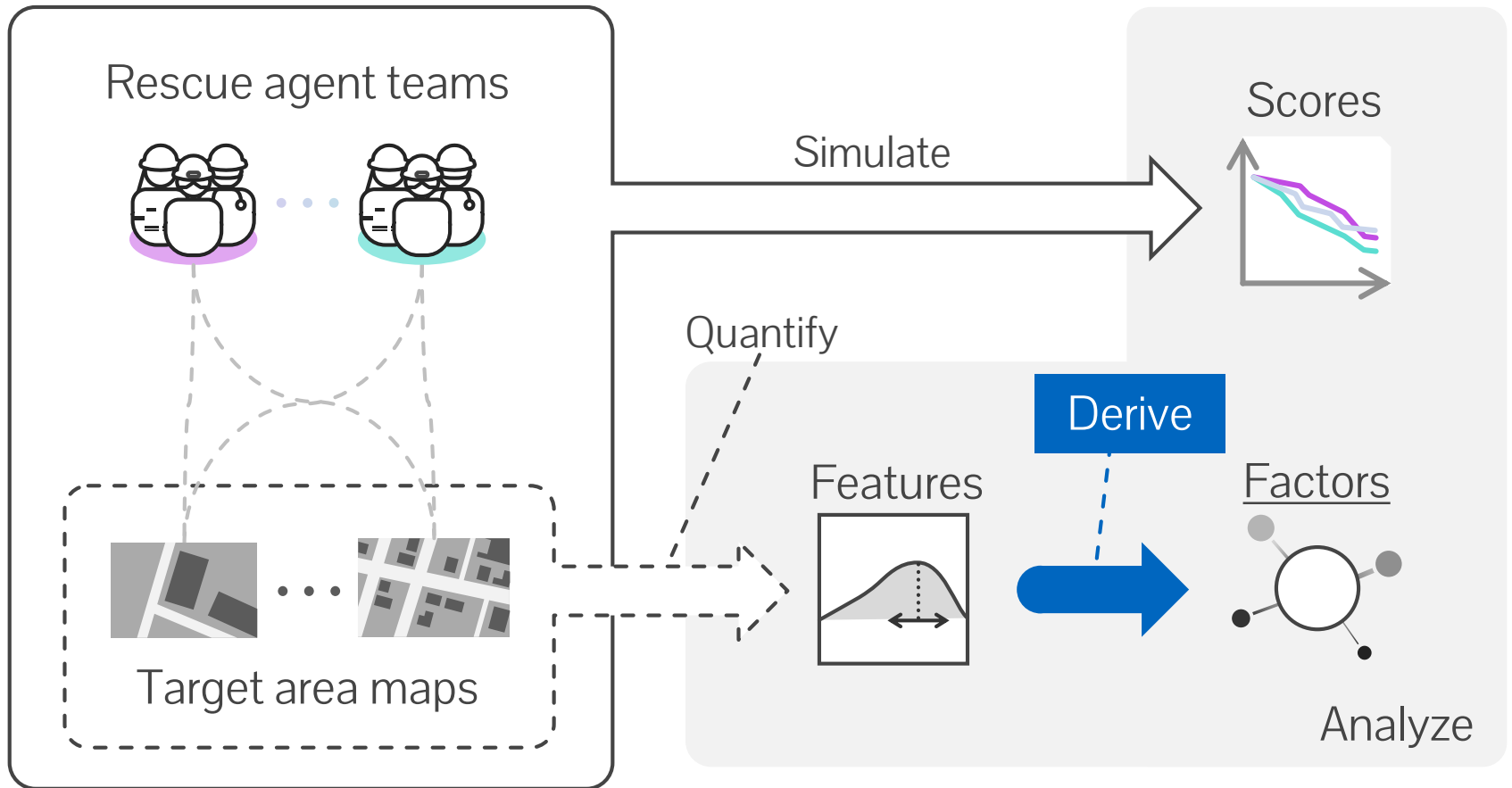
Analysis flow of previous studies



¹K. Iwata et al. (2011), N. Ito et al. (2014)

²D. Obashi et al. (2015), Y. Hosoya et al. (2020)

Key points to consider for the analysis flow of this study



To derive common environmental factors with analyses of the relationship between the scores and the map features

Evaluating agent capabilities through simulations

Setting up the simulation conditions

Rescue agent
teams

3

×

City maps

1,000

×

Simulations

16

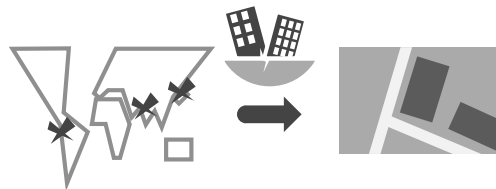


AIT

MRL

AUR

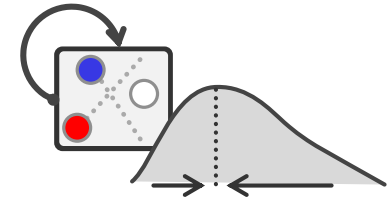
3 top teams
in the RoboCup Rescue
Simulation
world championships
from 2018 to 2020



794
areas

1,000
maps

1,000 Maps of cities
where earthquakes
may occur in the real
world



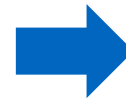
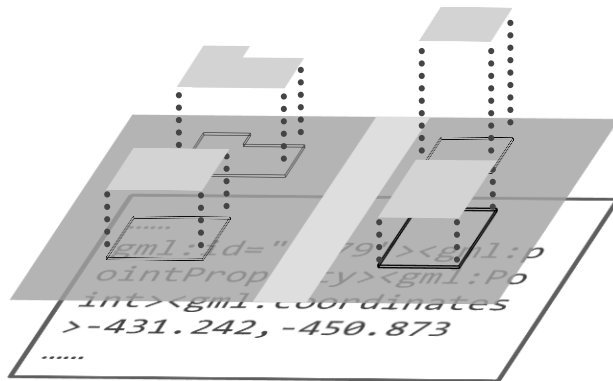
16 simulations
for each team and map

16 simulations
to obtain statistically
significant evaluation
values

Map quantification

Created 16 indices¹ dataset from 1,000 map data used in the simulation

Map structure



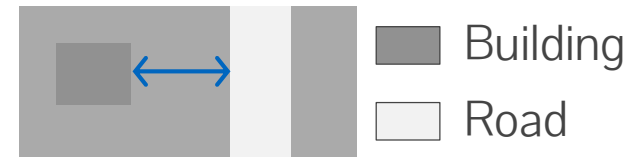
Dataset

c1	c2	...	c16
-0.49	-0.69		-0.89
1.02	0.70	•	-1.13
0.74	0.67	•	-0.36
:	:		:

16 indices (c1-16) are classified into 5 elements² of map structure

- I. *Building coverage ratio*
- II. *Building attributes*
- III. *Relationship between buildings*
- IV. *Relationship between building and road*
- V. *Density*

e.g., (c11) average distance to an adjacent road



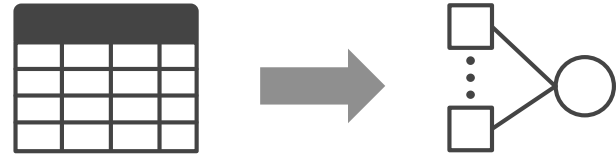
(IV. *Relationship between building and road*)

¹ K. Iwata et al. (2011) ² N. Ito et al. (2014)

Analysis procedure

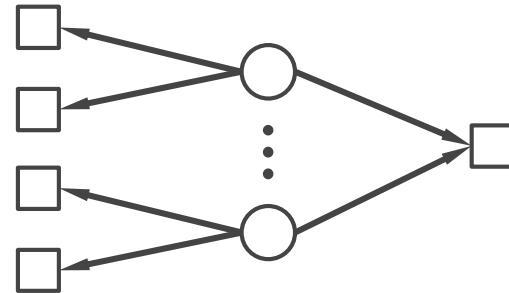
1

Deriving environmental factors from the map indices data set through factor analysis



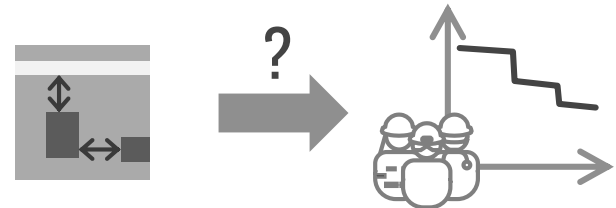
2

Modeling the relationship between the map features and the scores



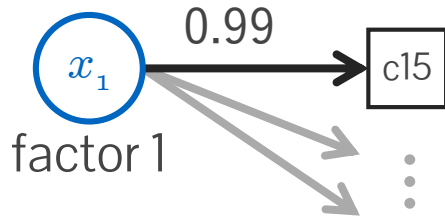
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Estimating the effects of environmental factors on the scores using covariance structure analysis



Environmental factors

The Results of factor analysis



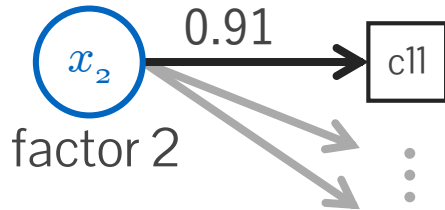
Factor 1 affects (c15) *the road density* strongly



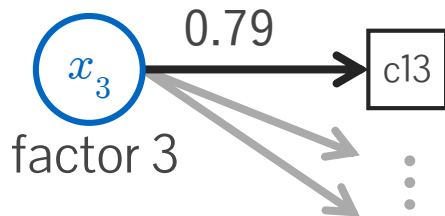
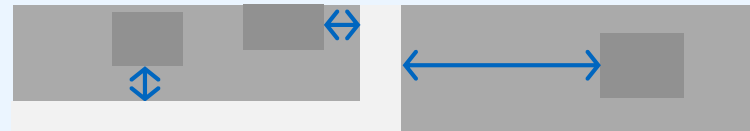
A few branch roads
(= low-density)



Many branch roads
(= high-density)



Factor 2 affects (c11) *the average distance to an adjacent road* strongly

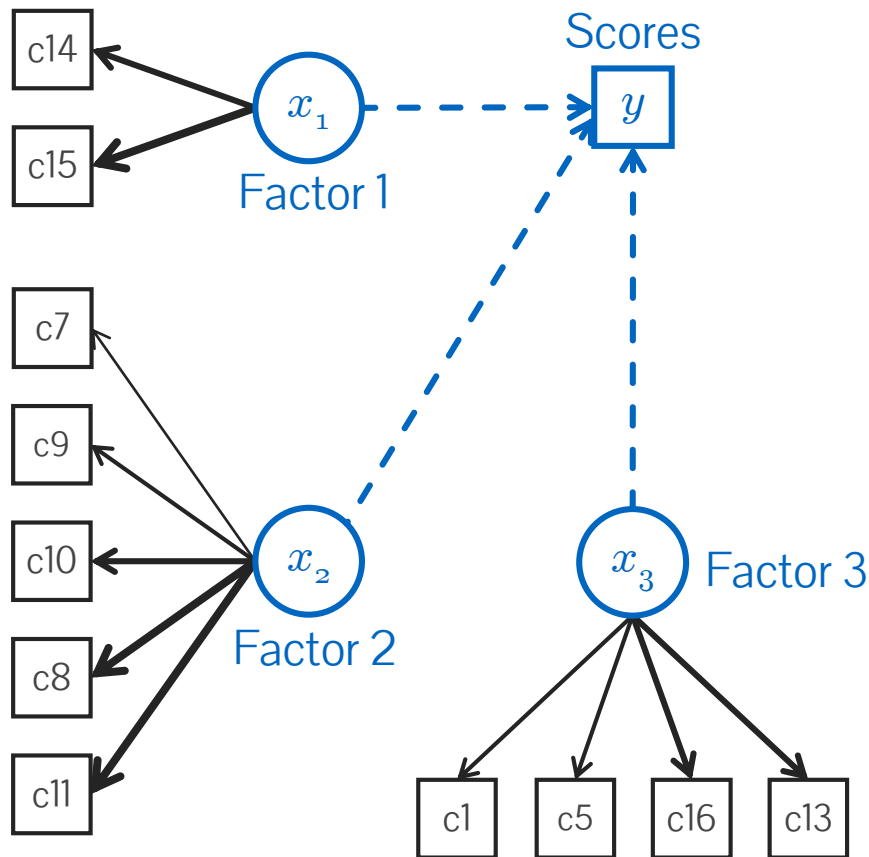






Factor 3 affects (c13) *the average number of adjacent buildings for a road* strongly



Covariance structure model

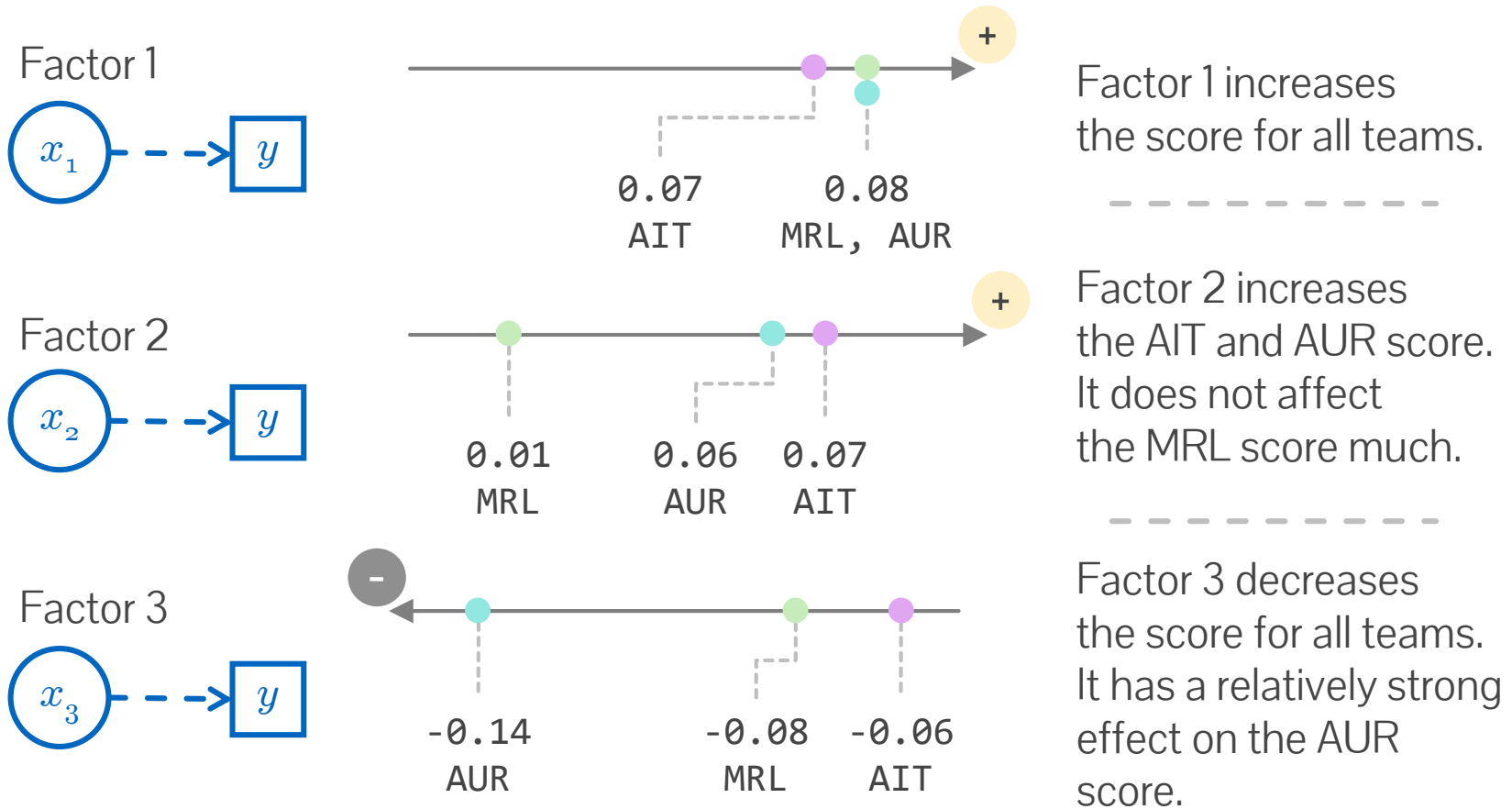
The environmental factors explain the relationship between the map features and the scores



-  Observable variables: map features and score
-  Unobserved constructs: environmental factor
-  Effect of factor on the map features (fixed by the results of factor analysis)
-  Effect of factor on the scores (different by each capability of agent teams)

Estimated results

The effects of environmental factors on each team score



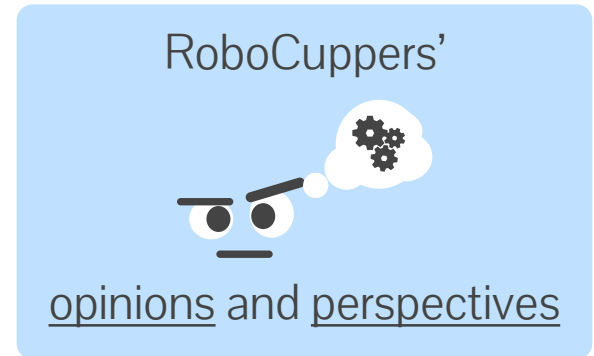
The three common factors make it possible to compare the agent teams

Interpretation of the results

An example of agent teams' evaluation using estimated results

Results

	AIT	MRL	AUR
Factor1	.07	.08	.08
Factor2	.07	.06	.01
Factor3	- .14	- .08	- .06



Three-stars ratings

		AIT	MRL	AUR
Handling Targets	Road	★ 2	★ 3	★ 3
	Civilian	★ 2	★ 1	★ 2
	Fire	★ 2	★ 2	★ 1
	Blockade	★ 1	★ 3	★ 2

How you look at the results may be different depending on your point of view.

Conclusion



It was impossible to compare different agent teams' capabilities.



Some teams perform better in certain environments.



We compared different agent teams' capabilities based on common environmental factors.



The proposed method can estimate the effects of the environmental factors on rescue operations using covariance structure analysis.



We made it possible to compare different agent teams' capabilities based on the estimated results.

