



RoboCup Rescue Simulation  
League 2020



# Introduction

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- Silhouette Analysis (Clustering)
- A\* Algorithm (Path Planning)
- Triage System (AT)
- Prevent Fire Spreading (FB)
- Help Stuck Agents (PF)

# Algorithm

Clustering & Path Planning

- Silhouette Analysis
- A\* Algorithm



# Silhouette Analysis

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## K-means++ algorithm (2019)

- The number of clusters was constant.
  - This method was unsuited to clustering in every map.

## K-means++ algorithm (2020)

- Silhouette analysis solved this problems.
  - Suitable number of clusters was chosen.

# Silhouette Analysis

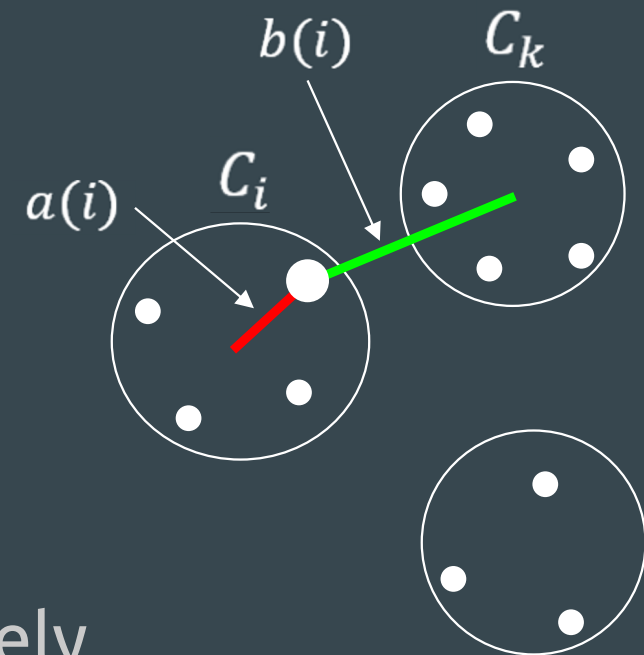
Silhouette value

$$a(i) = \frac{1}{|C_i| - 1} \sum_{j \in C_i} |i - j|$$

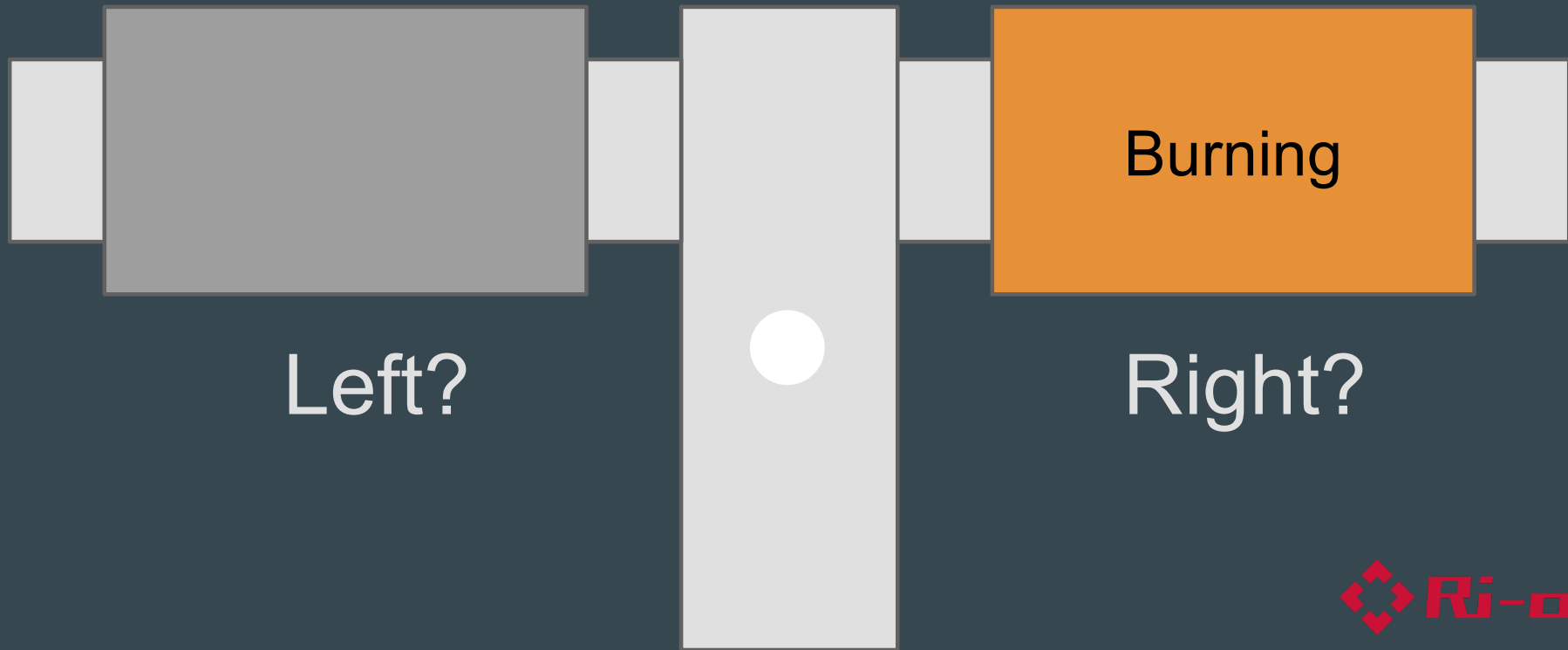
$$b(i) = \frac{1}{|C_k|} \sum_{l \in C_k} |i - l|$$

$$s(i) = \frac{b(i) - a(i)}{\max\{a(i), b(i)\}} \quad (-1 < s(i) < 1)$$

- Clustering is performed appropriately  
→ The higher Silhouette value



# A\* Algorithm (2019)



# A\* Algorithm (2020)

A\*

Actual Cost

The distance of  
parent node

+

Temperature

Heuristic

Distance of goal

# Ambulance Team

## Triage System

- Giving priority
- Grouping by HP





# Triage System | abstract

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- **Triage** means:  
*“the process of quickly examining patients ...  
... in order to decide which ones are  
the **most seriously ill** and must be **treated first**”*  
(Cambridge English Dictionary)
- Implementation : Grouping civilians by their HP

# Triage System | grouping

- Set priorities based on **Civilians' damage**
- The ATs **abandon** critically damaged civilians

The Life Period	The Priority
0 ~ 5	Not Rescued
5 ~ 50	First
50 ~ 100	Second
100 ~ 150	Third
150 ~	Fourth

# Fire brigade

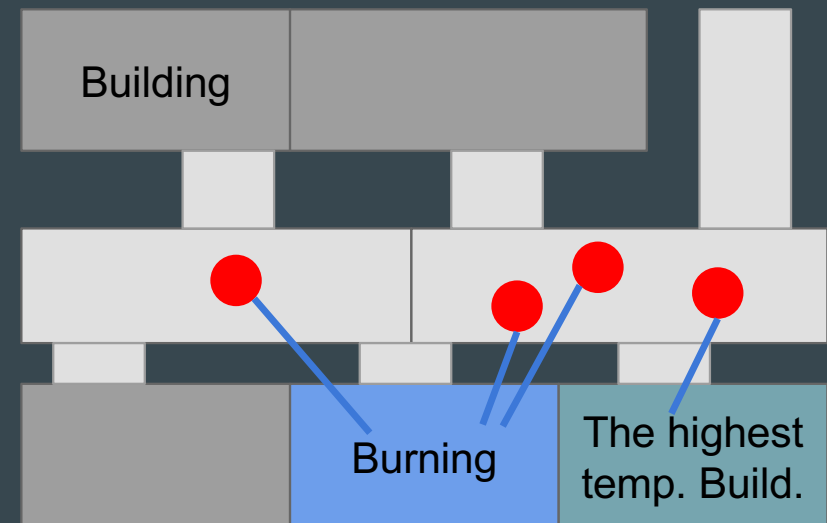
Prevent Fire Spreading

- New priority system
- Consider density



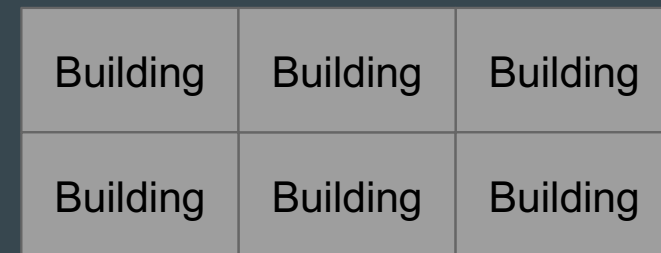
# Beforehand extinguish(2019)

- “Beforehand extinguish” has been adopted to the FB
  - Extinguish the highest temperature building near the burning building.
- In this year, expand this idea



# Prevent Fire Spreading | basic idea

- The **density** of buildings affects spread of fire
- **crowded** buildings  
→ higher risk
- The FBs extinguish **crowded** buildings first



high risk (crowded)



low risk (not crowded)

# Prevent Fire Spreading | Evaluation

- The priority is calculated with this formula:

$$\text{Priority} = \frac{\textit{Temperature}}{\textit{number of surrounding buildings}}$$

- use not only temperature, but also **density**
- Smaller Value → **High Risk**
- Larger Value → **Lower Risk**

# Police Forces

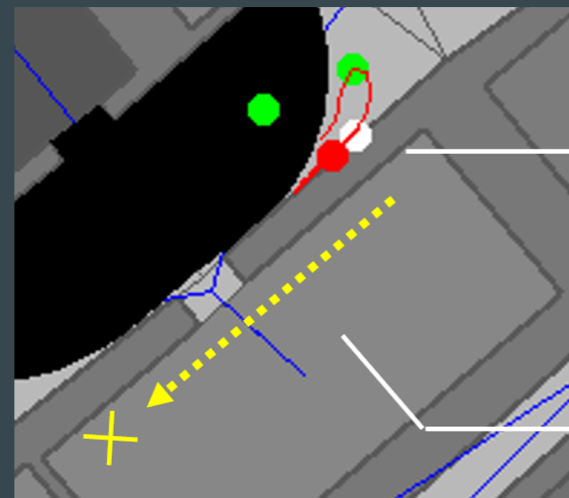
Help Stuck Agents

- Clear critical blockades
- Adjust range



# Help stuck agents | Problem

- Agents are often bothered by a **single** mass of blockades
- It causes “**stuck**”;  
Many agents **wasted** time trying enter forcibly



Stuck agents

Direction to targets



# Removing Stuck | Resolution

## 2019's Priority :

- whether agents are **buried or not**
- stuck agents often ignored...

## 2020's Priority :

- **whether make agents stuck**
- even though agents are **not buried**

→ Find blockades around them “stuck” agents



# Improve the Efficiency of Removing

- The PFs often tried to clear blockades from a distance
  - The PFs failed to clear blockades
  - That caused “Freezing” for PF
- Adjust range: The PFs clear from **closer** distance
  - 2019 : **100%** range of the PFs’ ability
  - 2020 : **50%** range of the PFs’ ability

# Result

Score and Summarize



# Result

Team	Map		
	kobe	berlin	sakae
Ri-one 2020	175.38	54.61	71.57
Ri-one 2019	167.91	38.36	70.56

# Summarize

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- Silhouette Analysis (Clustering) : **Exclude** Magic Numbers
- A\* Algorithm (Path Planning) : Choose **safe** path
- Triage System (AT) : Rescue based on **priority**
- Prevent Fire Spreading (FB) : Take **density** into account
- Help Stuck Agents (PF) : Clear **critical** blockades