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**Lecture with Computer Exercises: Modelling and Simulating Social Systems with MATLAB**

# **How do participants act during an apéro at ETH?**

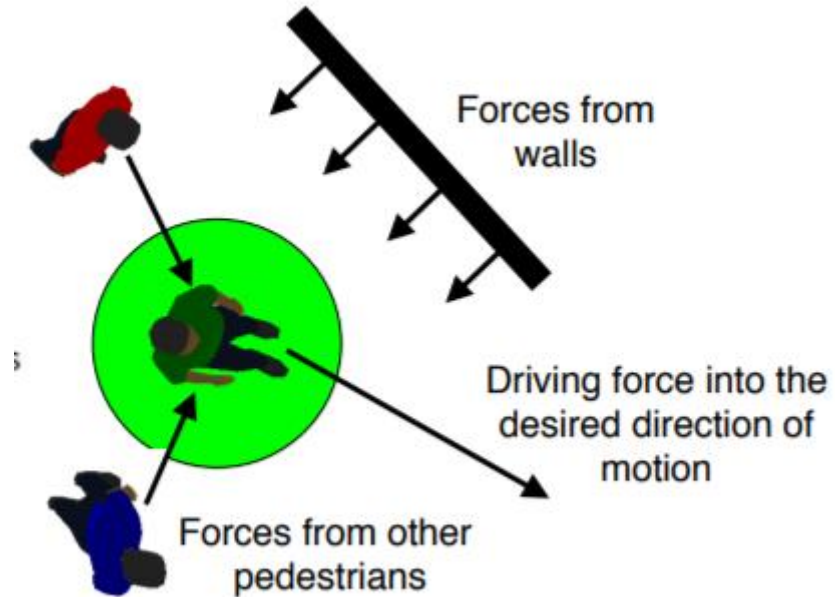
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# List of Contents

- Introduction and Motivation
- Description of the Model
- Implementation
- Simulation
- Results and Discussion

# Introduction and Motivation

## Social Force Model



$$\underbrace{\frac{dv_{\alpha}}{dt}}_{\text{acceleration}} = \underbrace{\frac{1}{\tau_{\alpha}}(v_{\alpha}^0 e_{\alpha}^0 - v_{\alpha})}_{\text{driving force}} + \underbrace{\sum_{\beta(\neq \alpha)} F_{\alpha\beta}^{\text{int}}}_{\text{interactions}} + \underbrace{F_{\alpha}^{\text{walls}}}_{\text{boundaries}}$$

# Introduction and Motivation

How does the number of

- People
- Food / drinks
- Tables (and their disposition)

affect the behavior of the participants ?



## Description of the Model

- Force due to Destination

- Considering a pedestrian  $\alpha$ :

$$\vec{e}_\alpha(t) := \frac{\vec{d}_\alpha - \vec{r}_\alpha(t)}{\|\vec{d}_\alpha - \vec{r}_\alpha(t)\|}$$

Desired velocity direction

$$F_\alpha^0(\vec{v}_\alpha, \vec{v}_\alpha^0 \vec{e}_\alpha) := \frac{1}{\tau} (\vec{v}_\alpha^0 \vec{e}_\alpha - \vec{v}_\alpha)$$

Force on a pedestrian due to destination

- Force due to other pedestrians

- Monotonic decreasing force field with elliptical shape

$$\vec{f}_{\alpha\beta} := -w \nabla_{\vec{r}_{\alpha\beta}} V_{\alpha\beta}[b(\vec{r}_{\alpha\beta})] \quad \text{with} \quad 2b := \sqrt{(\|\vec{r}_{\alpha\beta}\| + \|\vec{r}_{\alpha\beta} - v_\beta \Delta t \vec{e}_\beta\|)^2 - (v_\beta \Delta t)^2}$$

Explain w

- Pedestrian affected differently by people in front or behind him/her

## Description of the Model

- Force due to obstacles and walls
  - Monotonically decreasing force field

$$\vec{F}_{\alpha B} := -\nabla_{\vec{r}_{\alpha B}} U_{\alpha B} [b(\|\vec{r}_{\alpha B}\|)]$$

- Total Force
  - Summation of all forces

$$\vec{F}_{\alpha}(t) := F_{\alpha}^0(\vec{v}_{\alpha}, \vec{v}_{\alpha}^0 \vec{e}_{\alpha}) + \sum_{\beta} \vec{f}_{\alpha\beta} + \sum_B \vec{F}_{\alpha B}$$

# Implementation

- Person-Person repulsion

- Exponentially decreasing potential

$$V_{\alpha\beta}^0 e^{b/\sigma}$$

- Force multiplied by different coefficients considering the relative position of the people

- Table-Person repulsion

- The tables are obstacles while the people are directed to the food.

Table-person constant  $C_t=0.05$

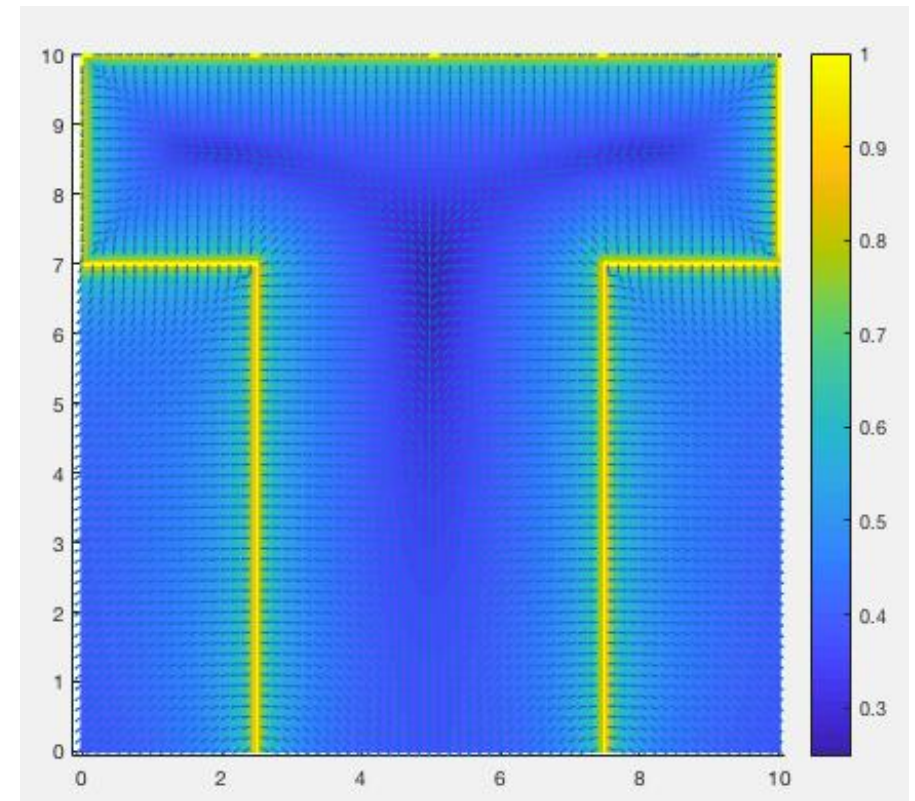
# Implementation

- Wall-Person repulsion

- Total repulsion force is equal to the superposition of all the point source contribution:

$$F_{wall-person} = \sum_i^N \frac{k}{D_{p-w,i}}$$

- Discretization of the Apéro room into a rectangular mesh of points





# Implementation

- Path towards the objective
  - Pedestrian follows the shortest polygonal route
  - 1<sup>st</sup> objective: Apéro table
  - 2<sup>nd</sup> objective: nearest table in the Apéro room

- Destination change

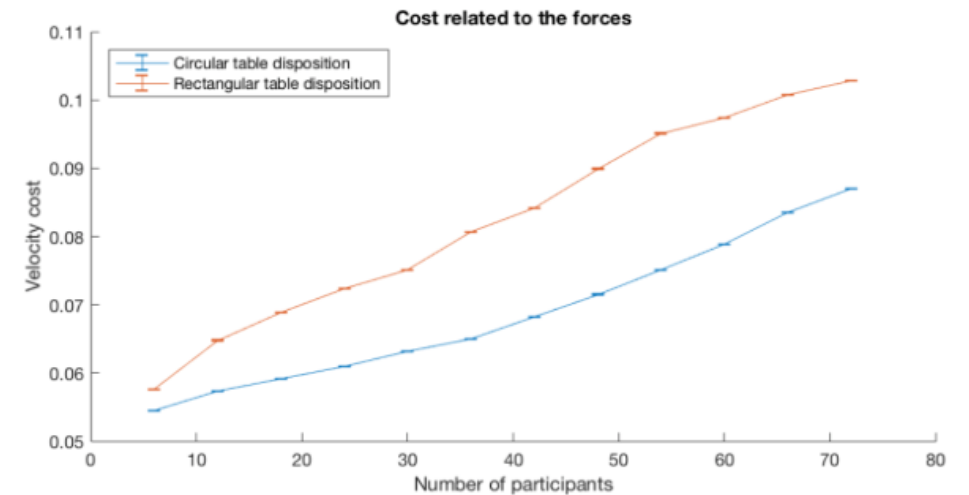
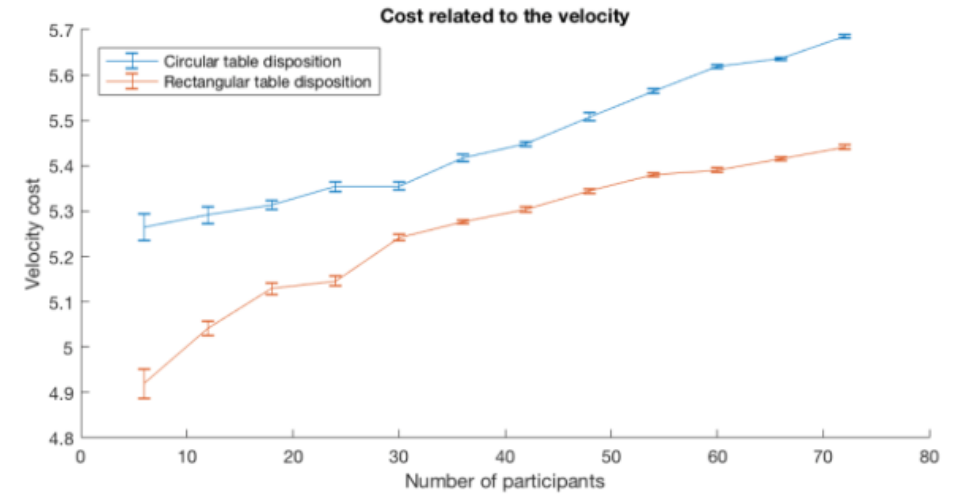
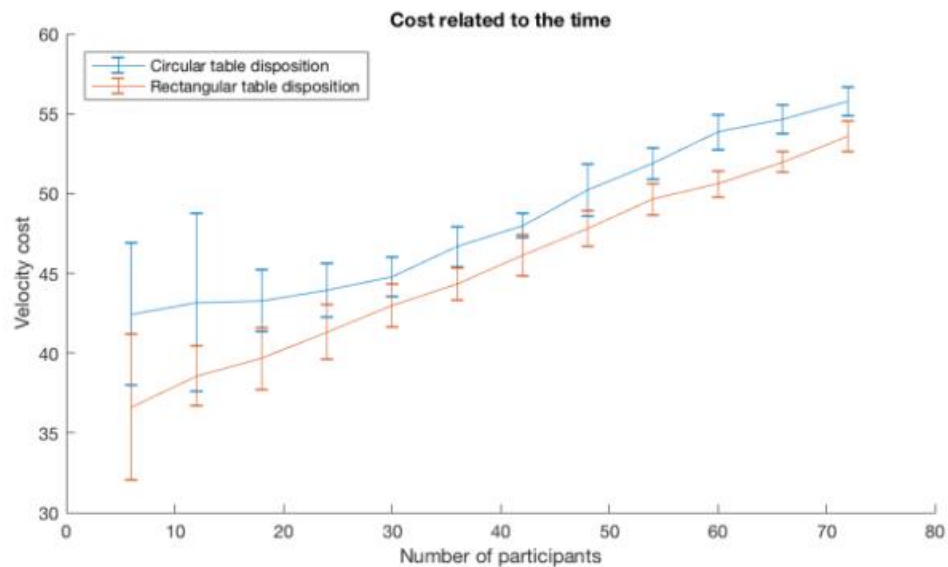
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if person has taken the food
    Sort the tables with respect to their distance to the person
    for i in sorted tables
        x = number of people going towards to ith table
        if x < table capacity of ith table
            set destination of person as the ith table
            break;
        end if
    end for
end if
```

# Simulation

- 3 functions are used to consider the cost of every simulations:
  - Time cost function
  - Velocity cost function
  - Force cost function
- Simulation conducted by averaging different simulations over 20 attempts each.  
The parameters that changed are:
  - Number of participants
  - Number of tables
  - Disposition of tables (circular or rectangular)
  - Distance between food positions on the buffet table

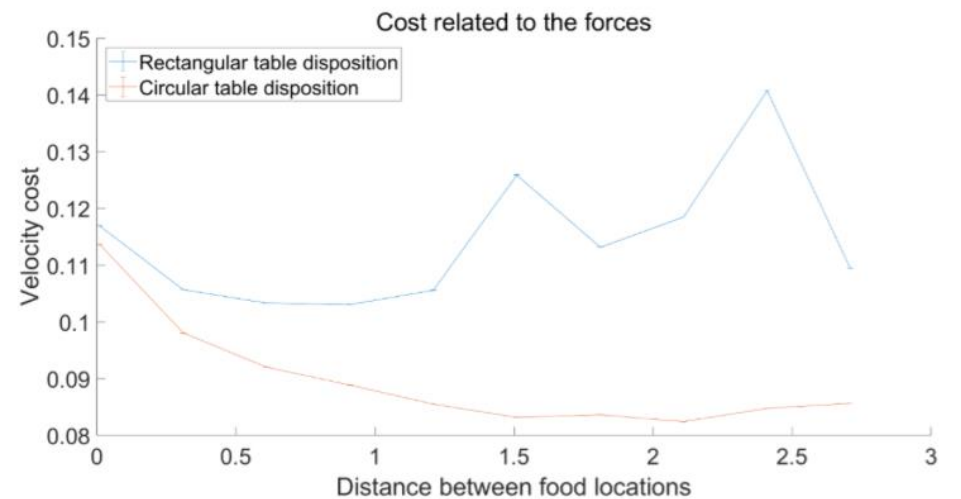
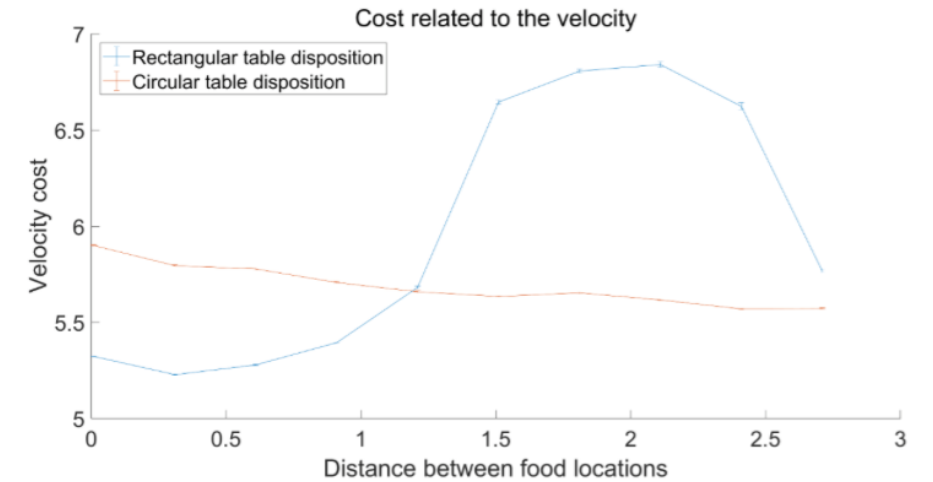
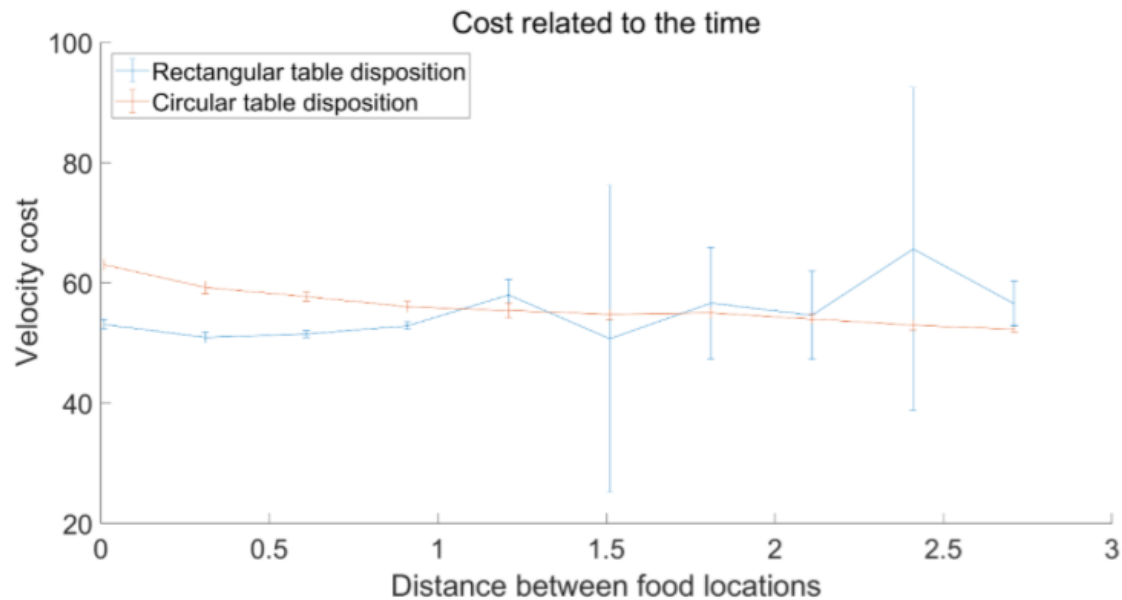
# Simulation

- Changing the number of participants



# Simulation

- Changing the food positions



# Results and discussion

%write something about final results and what configuration is better ecc...  
%Add videos

**Thank you**