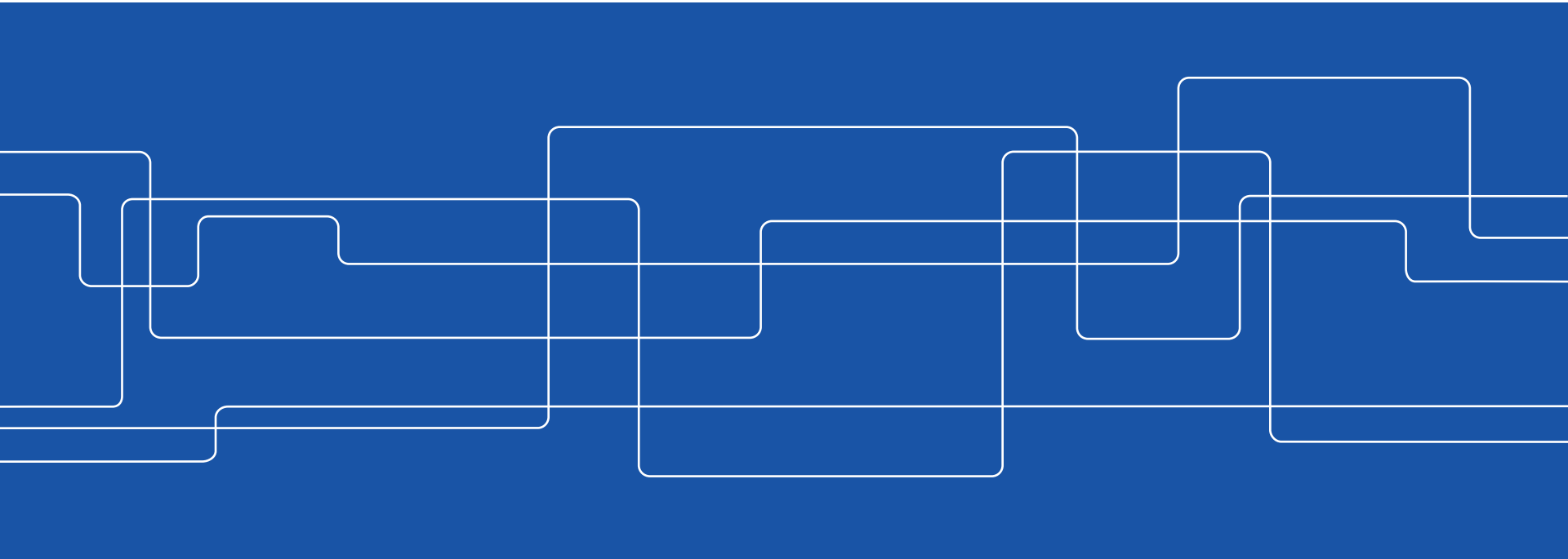




# High-density Crowds

A masters student's journey to graphics and multi agent systems





# Who am I and why am I here?

Jack Shabo, student of CDATE, year 2012

Doing a degree project in Crowd Simulations with Christopher Peters as a mentor

Has taken previous year's round of Computer Graphics and Interaction

- + Many other graphics courses

I'd like to share with you my experiences and give you inspiration for your projects!



# Layout

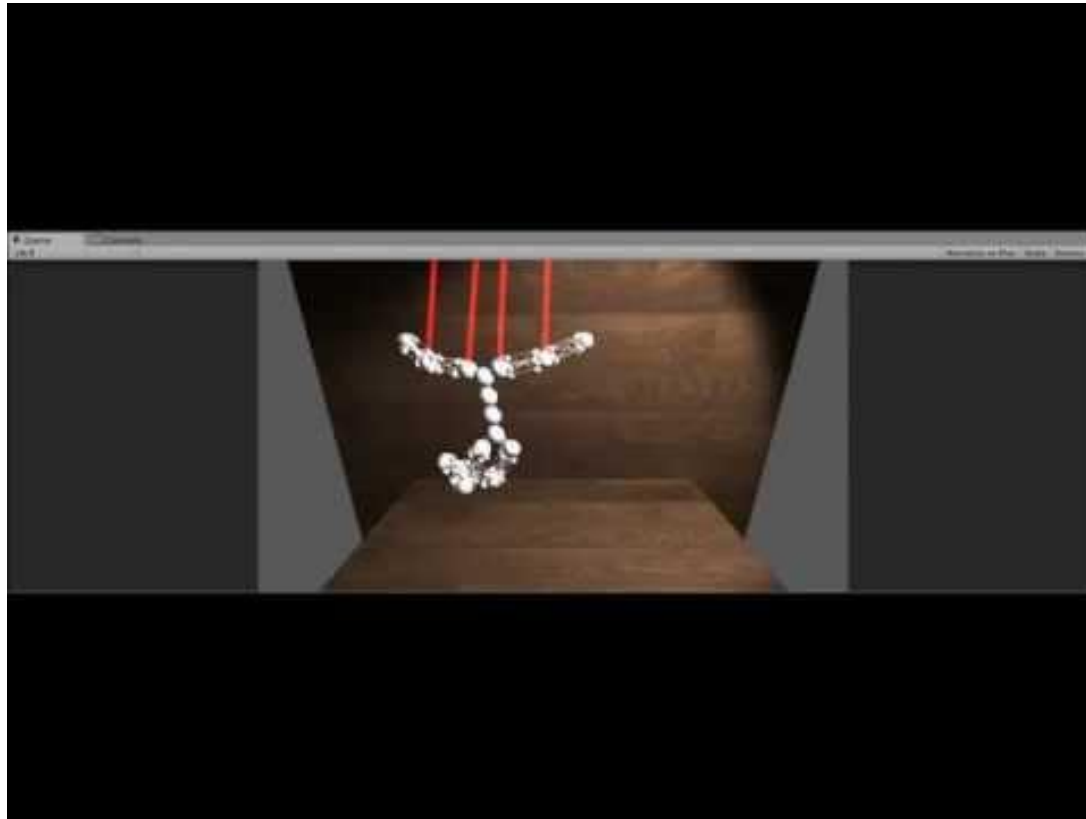
1. What I've been doing previously
2. What I've been doing recently
3. Where I'm going next
4. Where you can go next

# New at KTH!



# DD1354 - Models and Simulation

- My very first course with computer graphics
- Unity & Blender



# DH2323 - Computer Graphics and Interaction

Project result:

Helicopter simulation with (somewhat) real physics and joy-stick interaction





# DH2413- Advanced Computer Graphics and Interaction


Use more technologies: Virtual Reality (HTC VIVE, Oculus..), Augmented Reality (Mobile phones, infra-red sensors..)

Expand your knowledge of modern technologies and make something really outstanding. Take the “interaction” part more into consideration.

Exhibit at COMIC CON ←

# DH2413 - Comic con


**Pointy Stick**  
Release your inner Wizard



Virtual Reality      Unreal Engine

HTC VIVE

William Schröder	Max Lindblad
Haisheng Yu	Mathilde Caron
Jack Shabo	Henrik Karlsson



Teacher: Mario Romero







# Now: The master thesis

“High-Density Crowd Simulation with subgroups”

→ Multi-agent system with controllable people

Suggested by Christopher Peters

But.. why crowds?

- Architectural plans
- Optimizing pedestrian walkways
- Evacuation plans
- Social behavior
- . . .



## ... a HUGE area with LOTS of components

- Path Finding
- Rendering optimizations
- Real-life emulation
- Collision Detection
- Collision Response
- And then my focus area: Collision Avoidance
  - Using a **fluid based approach** to simulate 1000+ crowd agents in **real time**
  - Most crowd simulations can't simulate this in real time

→ Hardware restriction

# Example: Planet Coaster



# Example: High Density Crowd Assassins Creed Unity





# The “Unilateral Incompressibility Constraint” approach

*Problem: How do you keep crowd agents apart from each other? (Collision avoidance)*

Observations:

- Crowds are infinitely expandable, but not infinitely compressible.
- People want to keep a certain distance from each other
- Dense crowds has a reduced individual freedom of movement
- **People often walks in groups (My investigation)**



# Crowd properties

A crowd consist of many distinct individuals that each have a **position**, **velocity** and **goal**.

**Position:** World space location

**Velocity:** Speed determining how fast and where the individual is going.

**Goal:** A point in space that the individual will steer towards.

- General locations: (Restaurant, School, Home)
- Specific (partial) locations: (The bus station 200m ahead, Out of the shopping mall)



# The “Unilateral Incompressibility Constraint” approach

*Problem: How do you keep crowd agents apart from each other? (Collision avoidance)*

Solution: Do not consider the crowd as distinct agents. Instead, transform them into a **continuous representation** with:

- Density values at certain positions
- Velocity laid out on a large “velocity field”

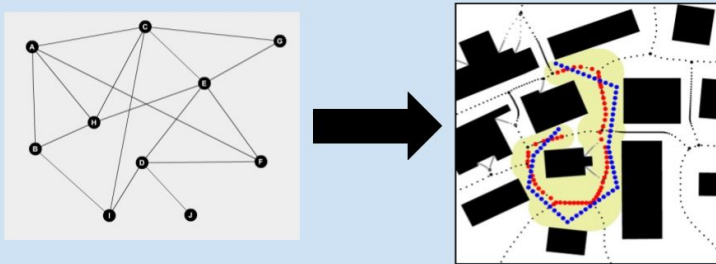
Unilateral approach: Introduce a “pressure” that corrects the crowd’s velocity when the density is too high. Feedback the corrected velocity to the **distinct** agents.





# Components of the simulation

## Global Planner



(Right) Image Source (2017, 04, 22)  
[https://www.staff.science.uu.nl/~gerae101/UU\\_crowd\\_simulation\\_publications\\_indicative\\_routes.html#contact](https://www.staff.science.uu.nl/~gerae101/UU_crowd_simulation_publications_indicative_routes.html#contact)

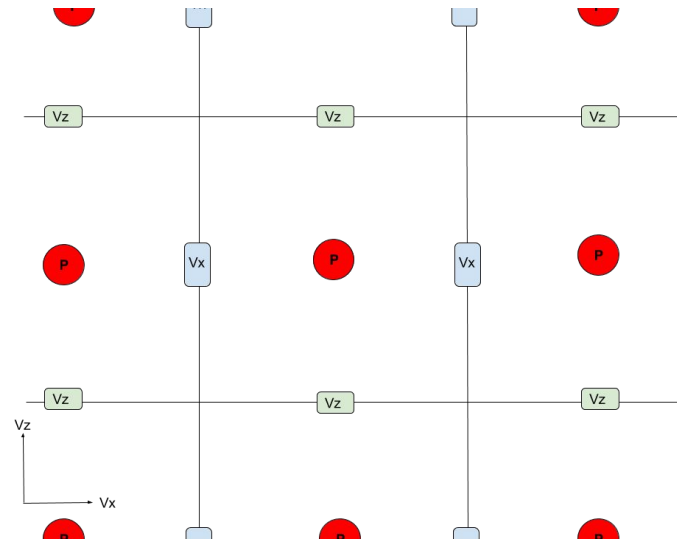


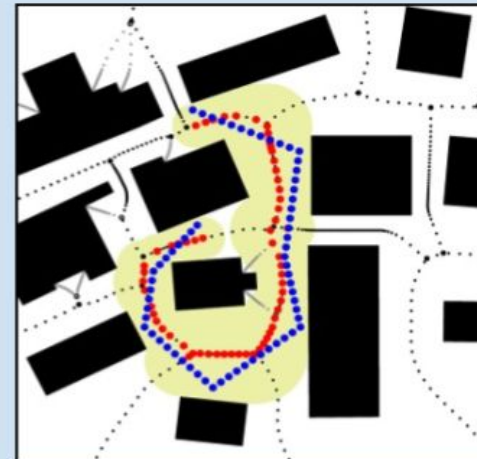
## Linear Compressibility Problem Solver

MPRGP

MPRGP with preconditioning in face,  
 MIC(0)

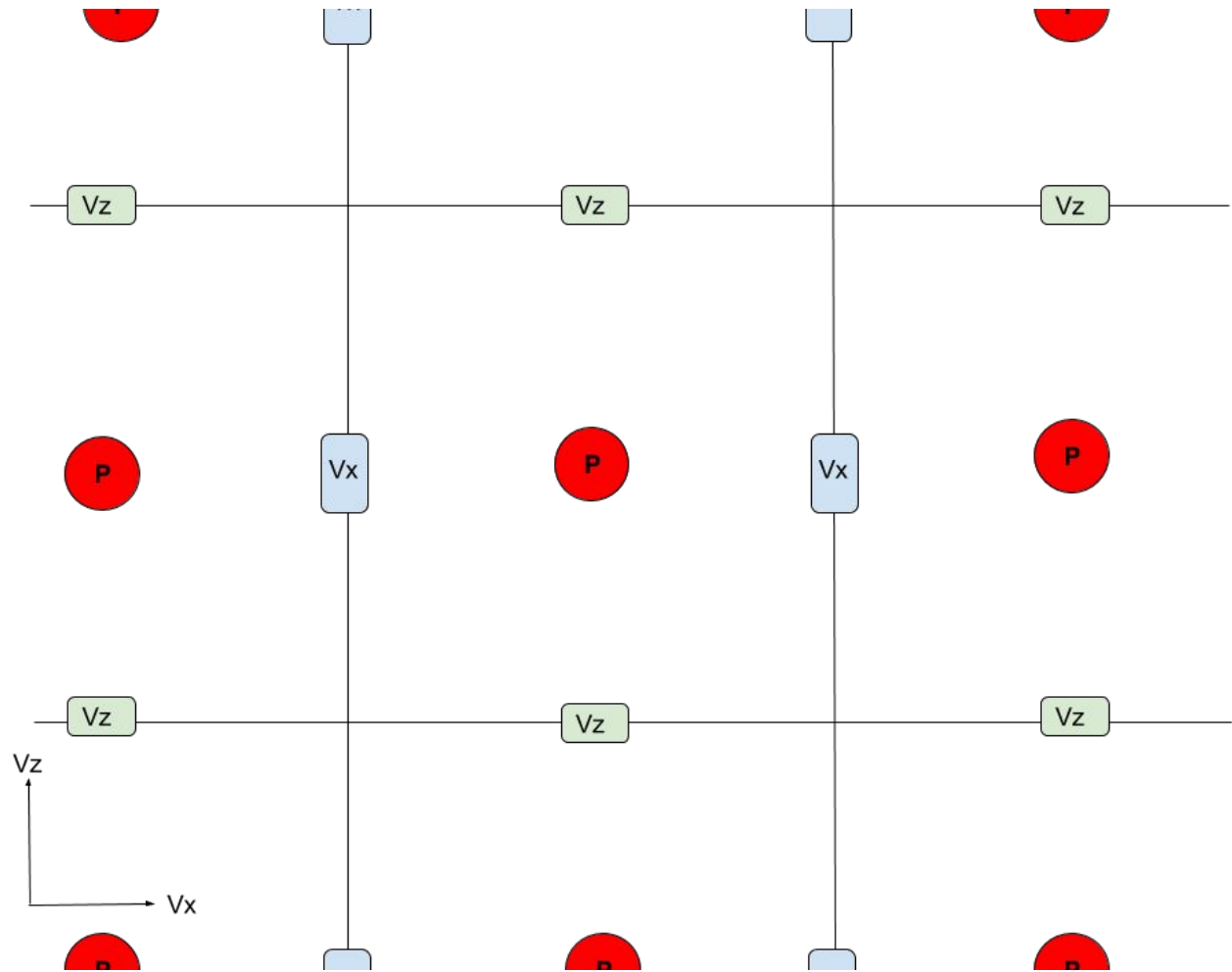
PSG PSOR





(Right) Image Source (2017, 04, 22)  
[https://www.staff.science.uu.nl/~gerae101/UU\\_crowd\\_simulation\\_publications\\_indicative\\_routes.html#contact](https://www.staff.science.uu.nl/~gerae101/UU_crowd_simulation_publications_indicative_routes.html#contact)

# Staggered Grid





# LCP Problem (Numerical Method solver)

## **Linear Compressibility Problem Solver**

MPRGP

MPRGP with preconditioning in face,  
MIC(0)

PSG PSOR

# Rendering agents

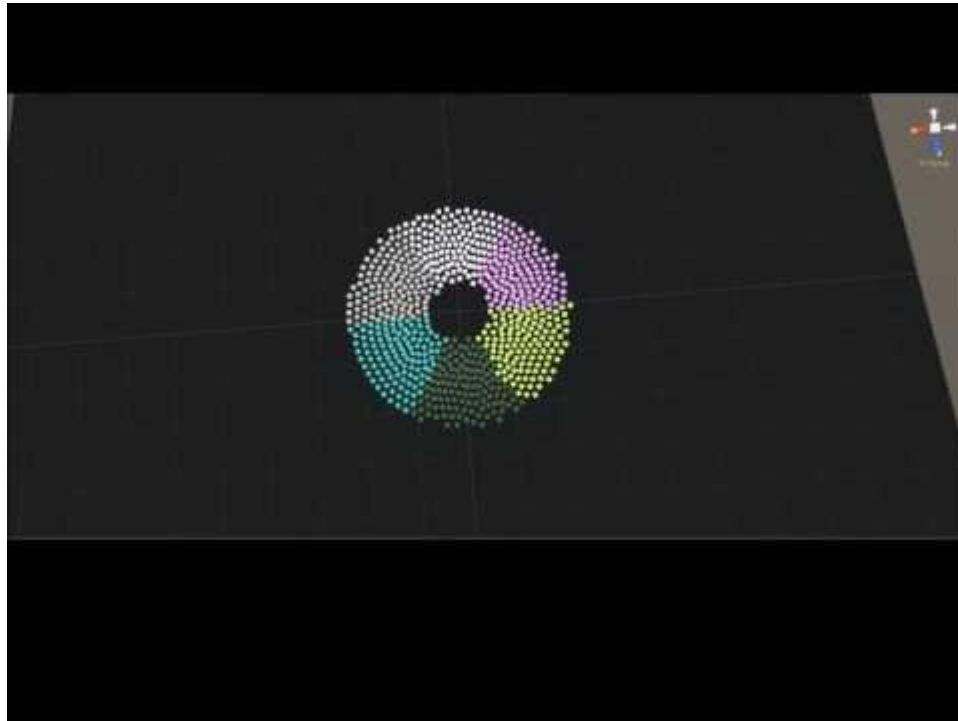
Low Poly Model



High Poly Model



# Demo video from my system





# Technologies used



C# for scripting and making most of the work



Unity as a game engine



Blender for 3D models / Animations (Mostly purchased)





# So what am I going to do next?

Continue to write a report..

Integrate evaluation methods..

Come up with scenarios..

..perform a **User Study** ← You



# User Study

- Detect subgroups in crowds of various densities.
- Sometime in the beginning of May (VIC Studio)
- Not very long - 15 minutes tops.



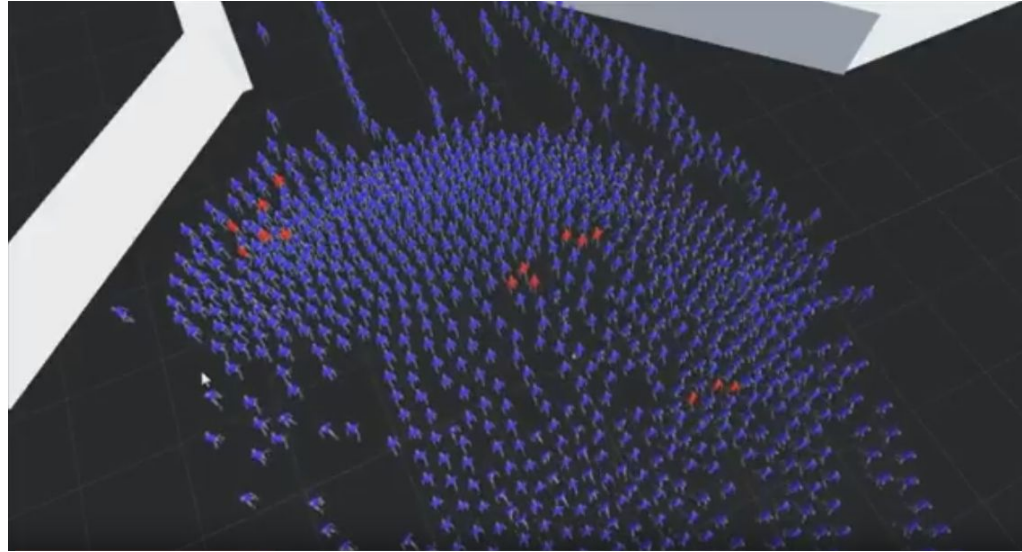
# How can YOU use my project in DH2323?

## **Project opportunities in DH2323**

- Improved pathfinding (Hand drawn paths?)
- Rendering with shaders on the GPU
- Render 3D models with smooth shading
- Extend simulation with moving obstacles
- See through the crowd's eyes using Virtual Reality
- Define better subgroups
- ...
- Your own suggestion!



# Thank you!



Jack Shabo

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