

CMP 756 – Swarm Systems

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- Office: Comp. Engineering Building – Room Z08
- Office hour: No prescheduled office hours, but feel free to set an appointment
- Attendance (%70): will be taken via zoom.
- Grading:

Project+Homeworks	60%
Final exam	40%

- Ref Book:
Veysel Gazi, Kevin Passino, Swarm Stability and Optimization, Springer, 1st Ed., 2012, ISBN: 978-3-642-18040-8.

Schedule (Tentative)

Week	Topic
1	Course Introduction and Mathematical Groundwork
2	Mathematical Groundwork (Continued)
3	Mathematical Groundwork (Continued)
4	Continuous time swarm coordination and control algorithms
5	Swarms of single integrator agents
6	Aggregation, formation control and tracking
7	Fully actuated agents and model uncertainty
8	Formation control with potential functions
9	Path Planning Algorithms
10	Path Planning Algorithms (Continued)
11	Swarm based optimization methods
12	Particle swarm optimization (PSO)
13	Ant Colony Optimization (ACO)
14	Genetic Algorithm (GA)

Swarm Systems

- Definition: A set of agents possessing independent individual dynamics but exhibit intimately coupled behaviours and collectively performing some tasks.

- Biological swarms

- Ants
- Bees
- Pack of wolfs

- Engineering

- Dancing Quadrotors
- Collective missile strikes
- Satallites
- UGV,UAV,AUV(UUV) group

Biological Swarms
Food searching
Path finding
Attack/Defence Mech.
Carrying an object
Communications: Chemical, via environment, signals (waggle dance of a bee)

Engineering Swarms
Monitoring
Searching
Cleaning mines
Mapping
Cultivating







TEAMS AUTOMATICALLY REROUTE AROUND POP-UP THREAT

40 UNIDIR

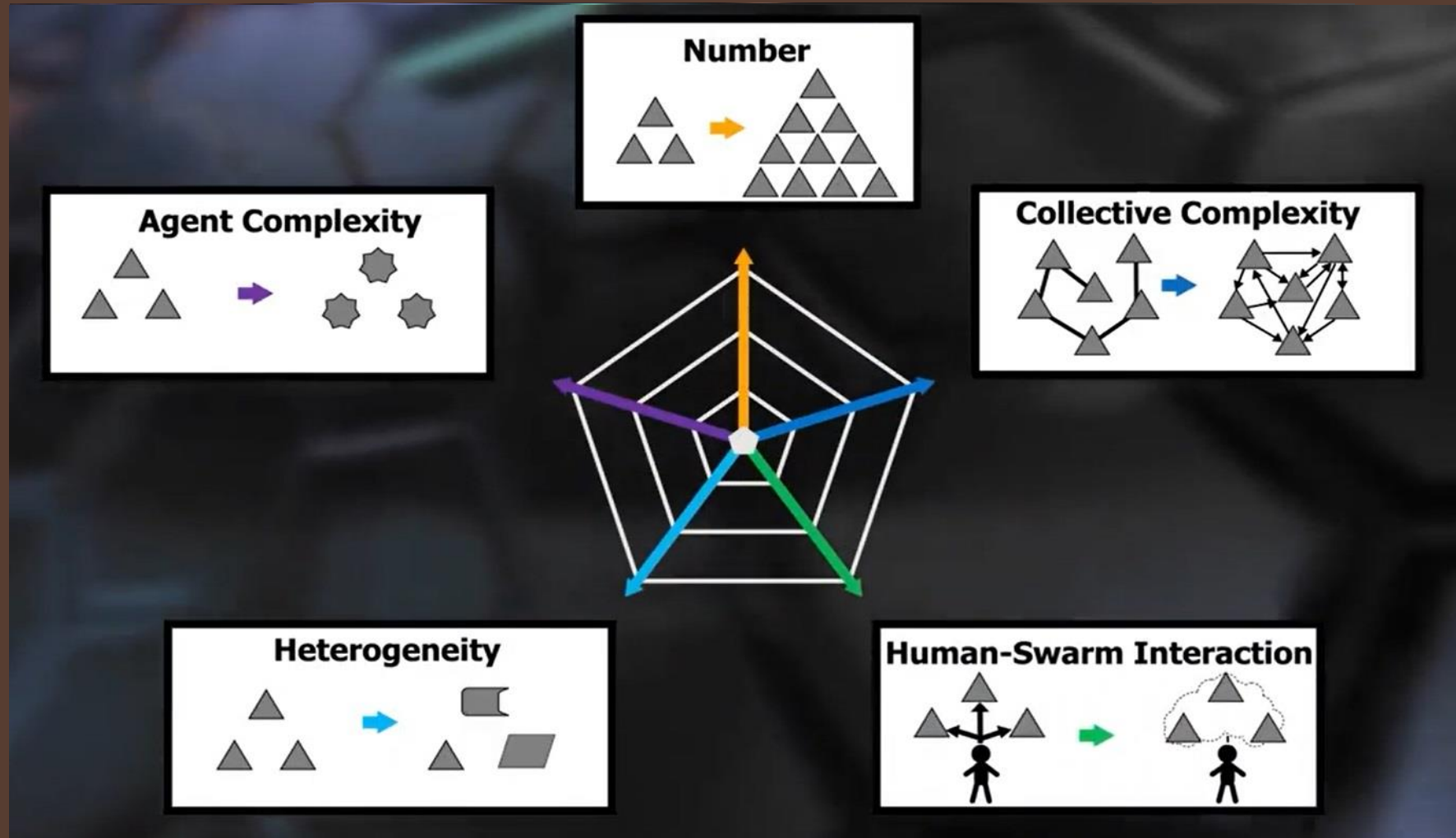


Pop-Up Thr

DARPA

ARTIST'S CONCEPT

Swarm Components



Generic Swarm Perspective

- Define agents
 - UAV,UGV,UUV or a collection of those, Software agents, Missiles, Satallites
 - Motion Dynamics (fast, slow) with limits
- Define sensory capabilities
 - Cameras, IMU as Position, velocity, acceleration, bandwidth, noise etc
- Define processing ability
 - DSP, FPGA etc
- Define communication
 - Direct communucation or via environment (by manipulating)
 - Ad-hoc wireless network
- Define actuator/sensor limitations

Some Remarks

- One can see a dynamic swarm system as a set of communicating agents which work collectively to solve a task
- Central control becomes ineffective as the number of elements of the swarm increases
 - Robustness issue
 - Computation capacity
- Advantages of Swarm with respect to single robot
 - More-Flexible: re-adjustable, reorganizable
 - Parallel operation
 - Fault tolerant

Goal

- Need to have stable agents
 - Lyapunov, small gain, Hurwitz
- Modelling and analysis of a swarm system
 - Individual based (Lagrangian)
 - Continuum (Euler)
- Coordination and control of a swarm system