

# MATLAB®/SIMULINK TUTORIAL

FOR: INSTITUTE OF POPULATION RESEARCH

Dr. Punit Tulpule

Research Assistant Professor

Mechanical and Aerospace Engineering Dept.  
Simulation Innovation and Modeling Center

# RESEARCH FOCUS

- Automotive Engineering:
  - Validation and verification of autonomous vehicles
  - Advanced powertrain control and estimation
  - Test case development for safety assessment
- System Modeling and Simulation
  - Model fidelity analysis
  - Information based approach for model selection

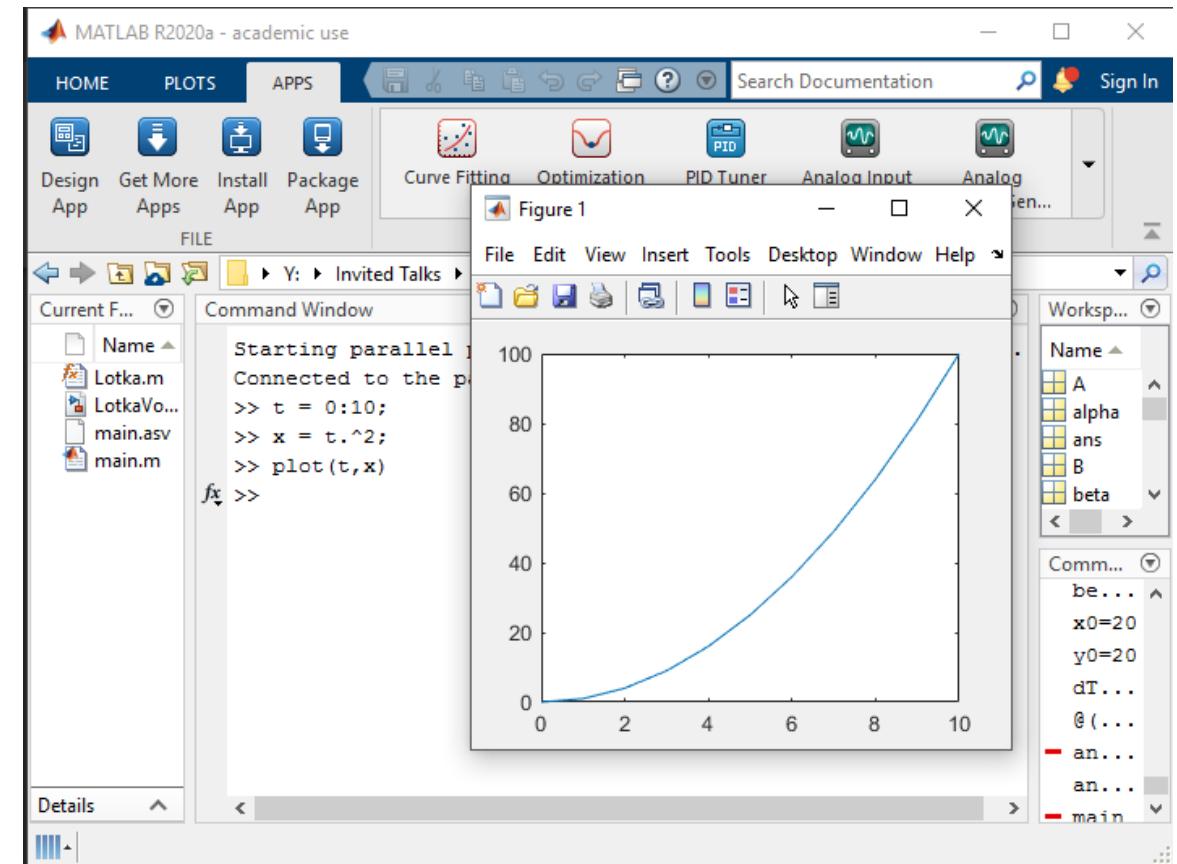


# AGENDA

- Introduction to MATLAB® and Simulink
- Applications pertaining to IPR
  - Data analytics
  - Modeling and simulation
  - Agent based modeling

# MATLAB- - Matrix Laboratory

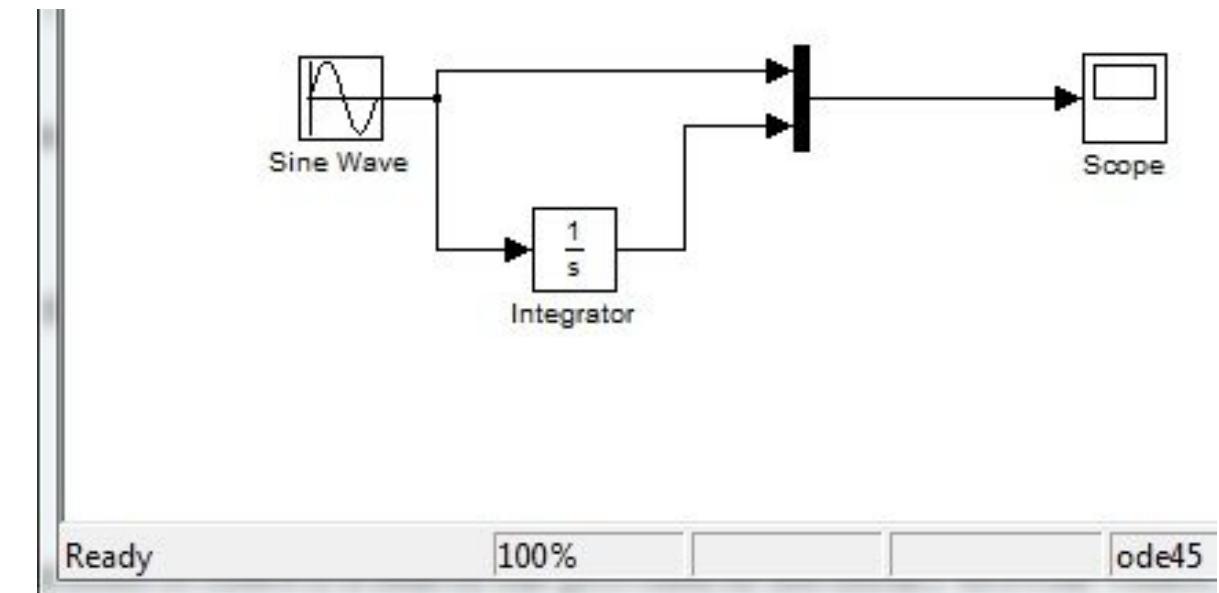
- Cleve Moler (Prof. At Univ. of New Mexico) started building a software tool for large matrix operations in 1970s.
- Mathworks – the parent company was founded in 1983
- The original versions of MATLAB was geared towards control engineering
- Now, MATLAB and Simulink have over 100 toolboxes
  - Data analytics
  - Solving equations (algebraic, differential, partial differential etc)
  - Optimization



<https://www.mathworks.com/products/alphabetical.html>

# SIMULINK

- MATLAB and Simulink are not different software tools
- Simulink® is a block diagram environment for multidomain simulation.
- Simulink® provides a graphical editor, customizable block libraries, and solvers for modeling and simulating dynamic systems.



# WHY (WHY NOT) USE MATLAB/SIMULINK

## Pros

- Large variety of toolboxes
- Excellent user community, online help and training
- Best in class solvers
- Fast growing and most state-of-the-art
- C++ based – hence generated codes are fast
- Parallel processing support
- OSU has license to full suite

## Cons

- Very bulky tool if many tools are installed
- Poor programming practices may slow down the program
- Not good for big data handling



# DATA ANALYSIS USING MATLAB

## Simple statistical data analysis

- Data import-export
- Statistics (mean, median, correlation etc.)
- Curve fitting, regression analysis
- ANOVA
- Filtering, resampling

## Machine learning, AI, big data

- PCA
- clustering
- Modeling/learning (fitting neural nets)
- Pattern recognition
- regression



# MACHINE LEARNING

## MACHINE LEARNING AND DEEP LEARNING



Classification  
Learner



Deep Network  
Designer



Experiment  
Manager



Neural Net  
Clustering



Neural Net  
Fitting



Neural Net  
Pattern Rec...



Neural Net  
Time Series



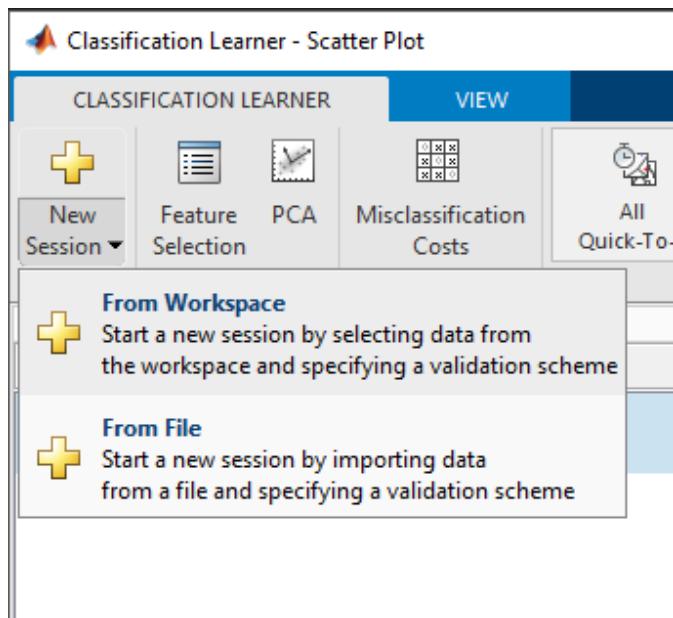
Regression  
Learner

- MATLAB provides a very user-friendly GUI to use machine learning methods
  - Has better programmatic options for pro users
- Most apps take the data (in a specific format) and perform training, validation, and testing in a few clicks

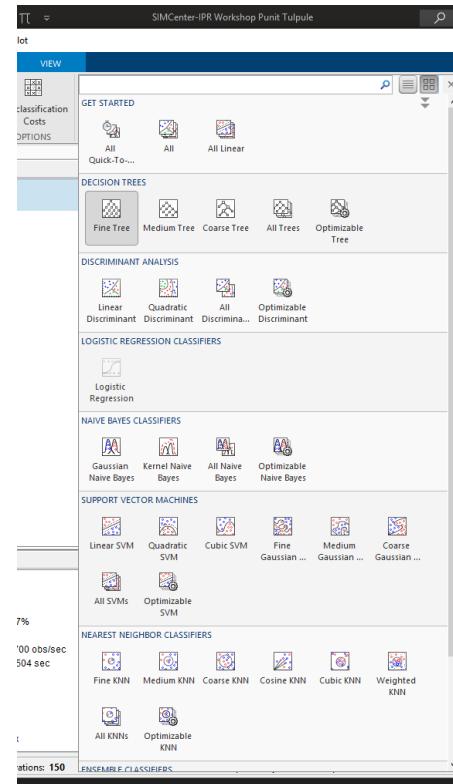
# TUTORIAL

- Load iris flower data:  
    >> fishertable = readtable('fisheriris.csv');
- Apps → Classification learner under machine learning

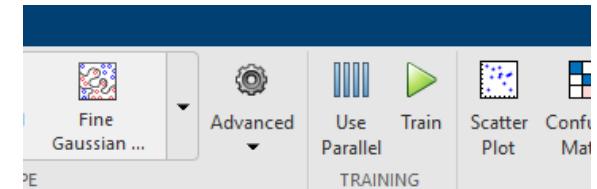
## 1. Load Data



## 2. Select Algorithm



## 3. Train



# SOLVE EQUATIONS

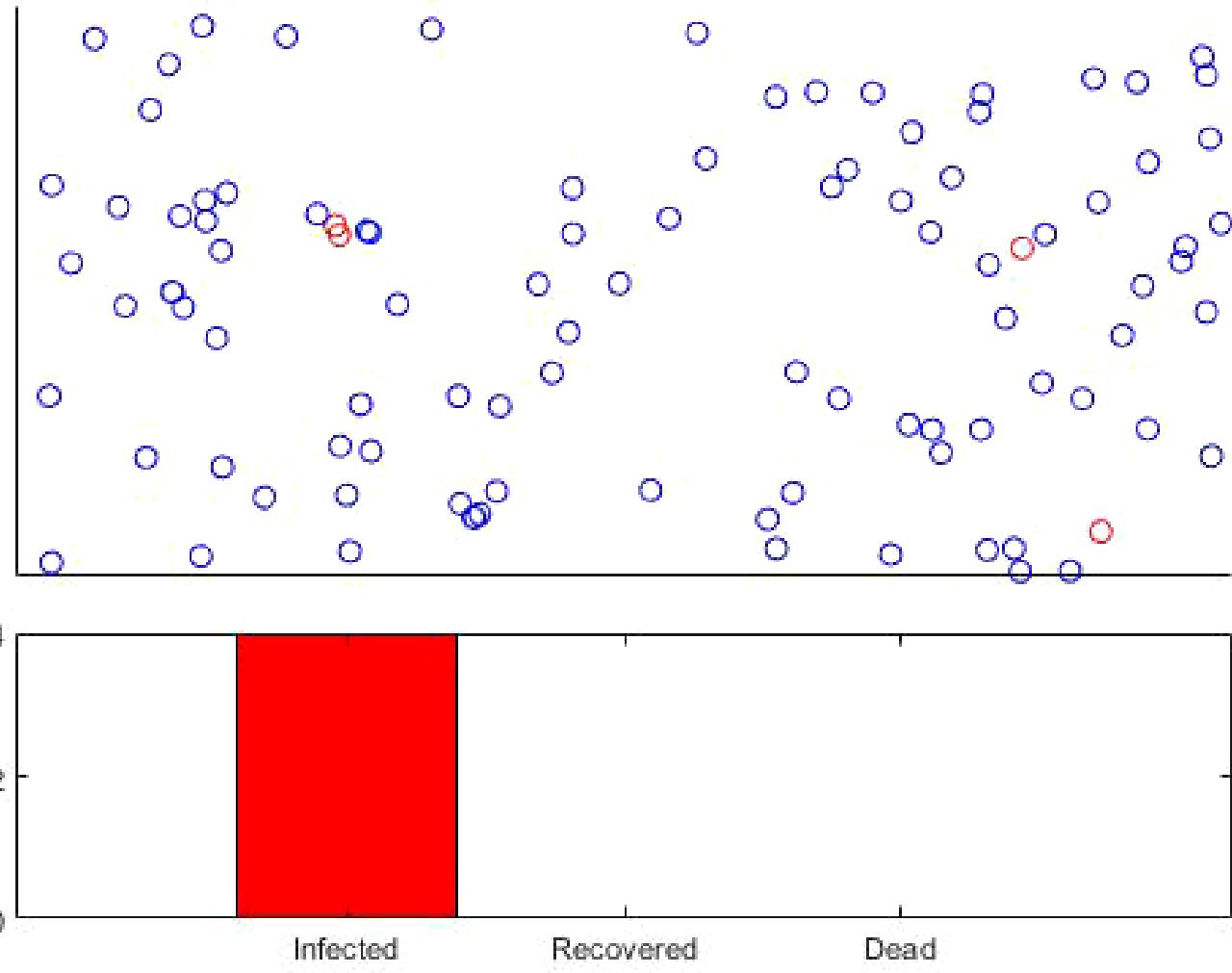
- MATLAB and Simulink solvers for differential equations are probably the best in class
  - Simple ODE solvers: Euler, Runge-Kutta etc.
  - Stiff solvers
  - Discrete time and continuous time
  - Fixed time and variable time step

# AGENT BASED MODELING

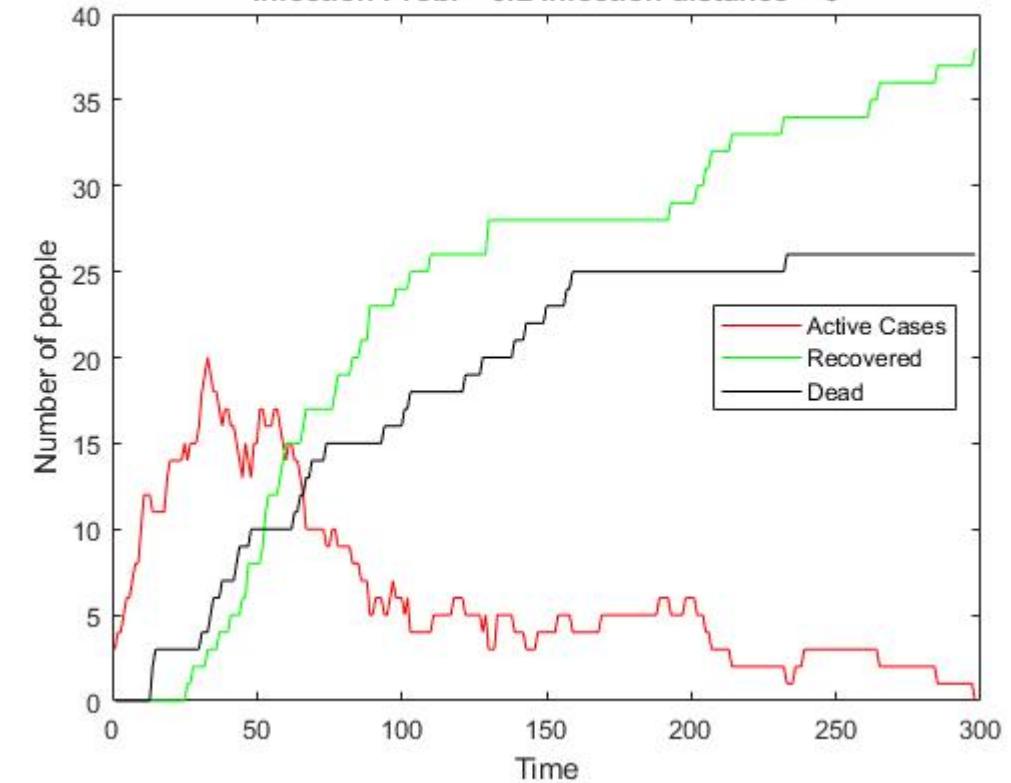
- Matlab is very well suited for
  - Object oriented programming (agent based programs)
  - Probabilistic and stochastic models
- Example: Infectious decease spread
  - Population of 100 people confined in a space but free to move around
  - Three people are infected with infectious decease (COVID?)
  - There is some probability that the decease will transmit to another person if the distance is less than a threshold
  - An infected person may die with some probability (1%)
  - An infected person will recover in certain period of time with some uncertainty

# INFECTIOUS DISEASE SPREAD SIMULATION

Infection Prob. = 0.2 Infection distance = 6

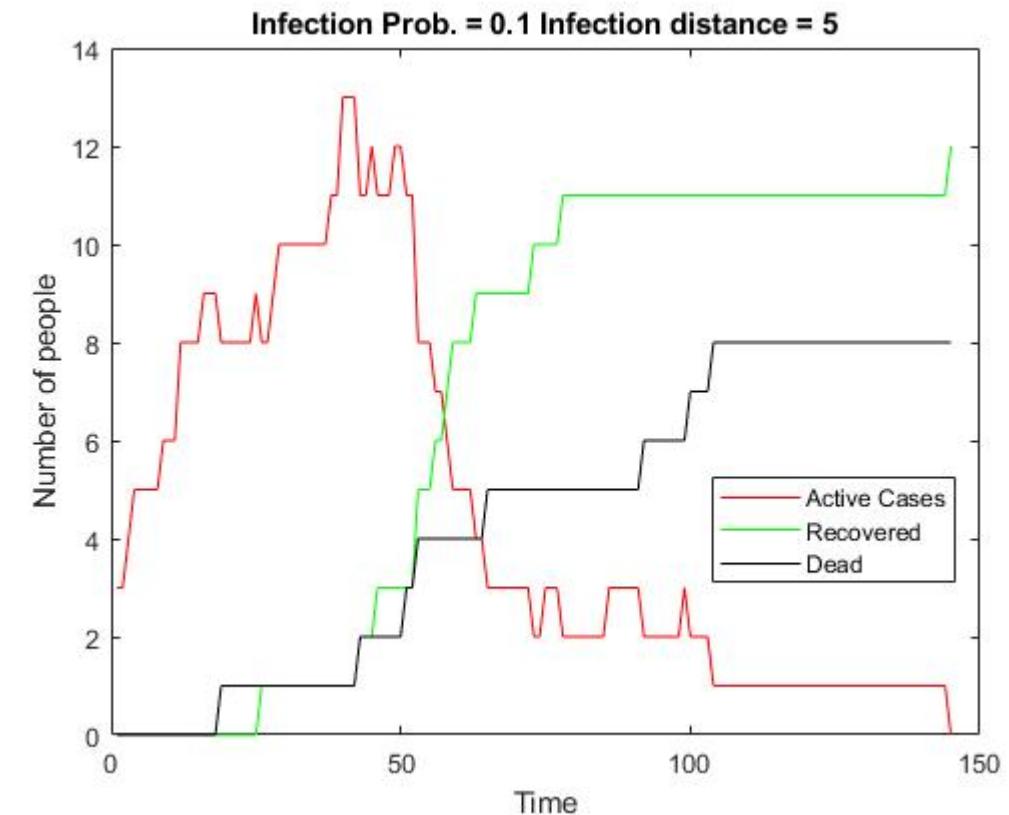
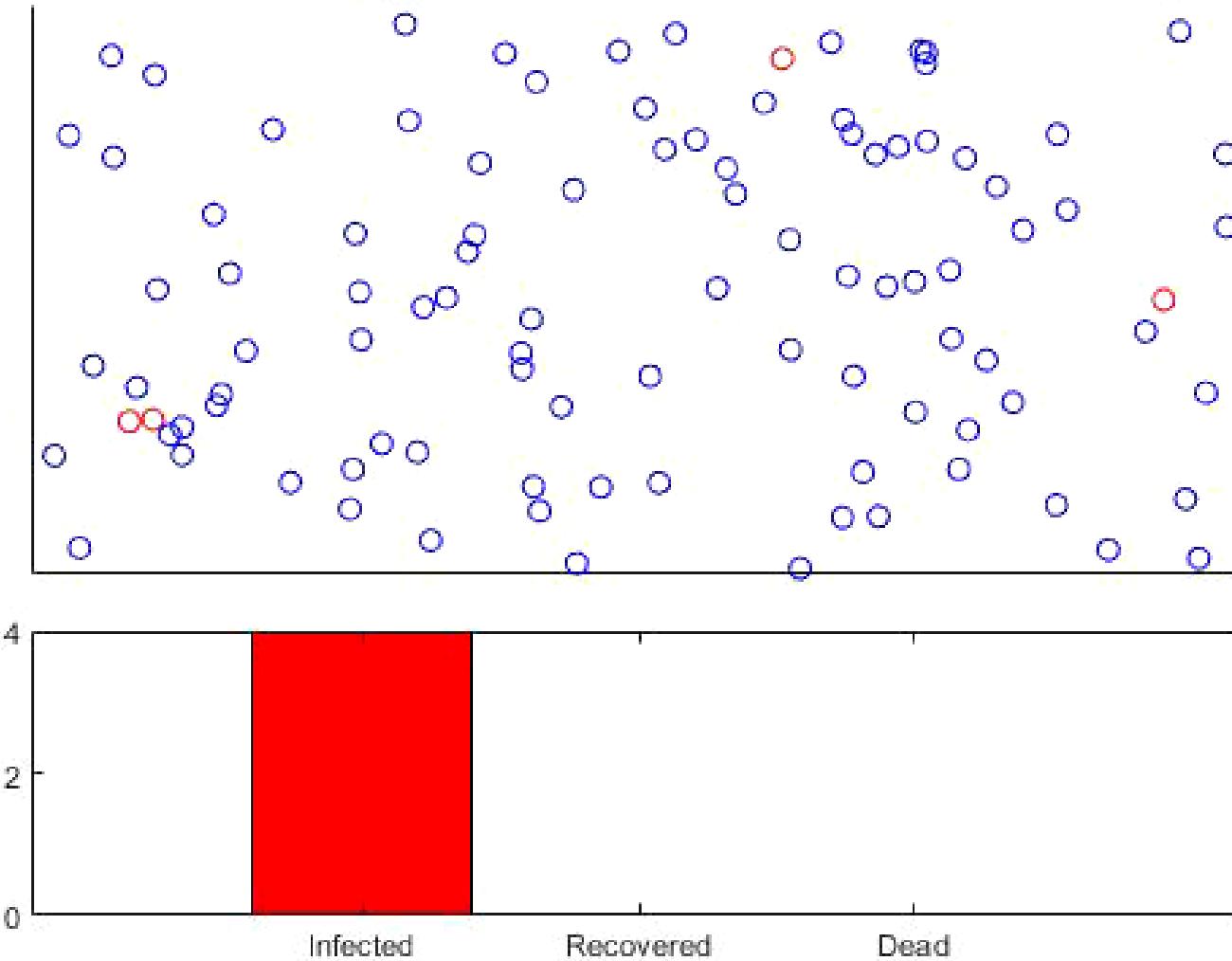


Infection Prob. = 0.2 Infection distance = 6



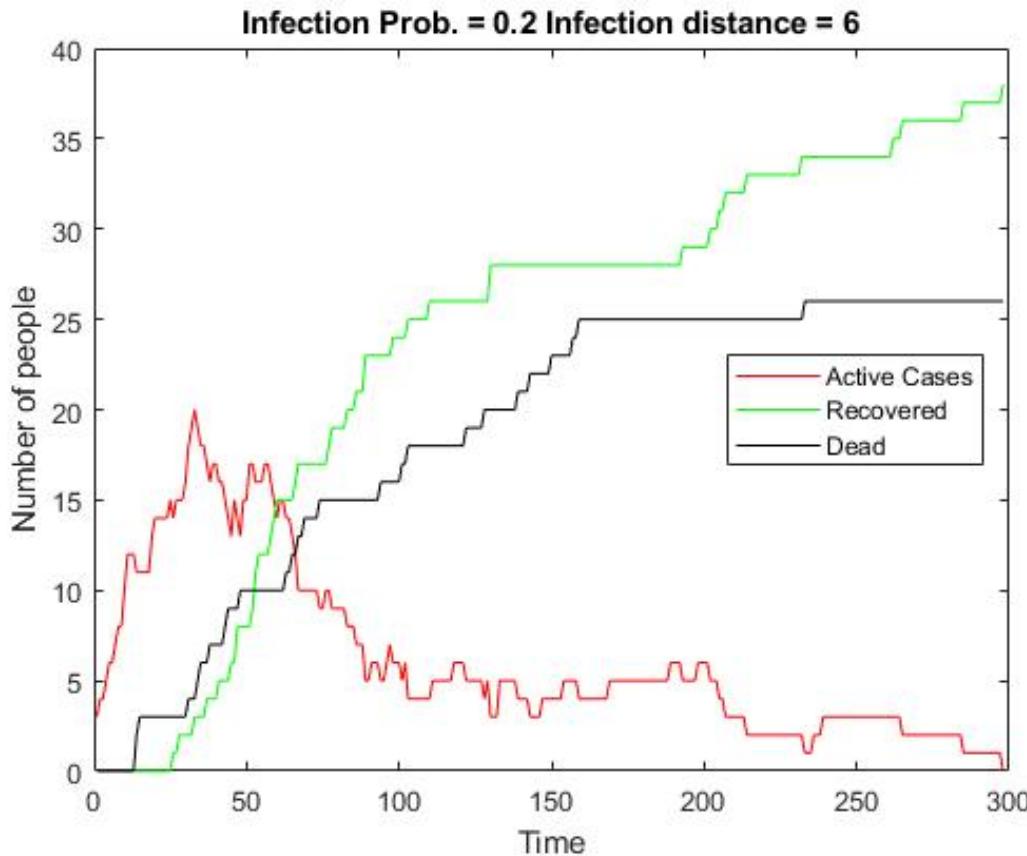
# WITH MASKS ON

Infection Prob. = 0.1 Infection distance = 5

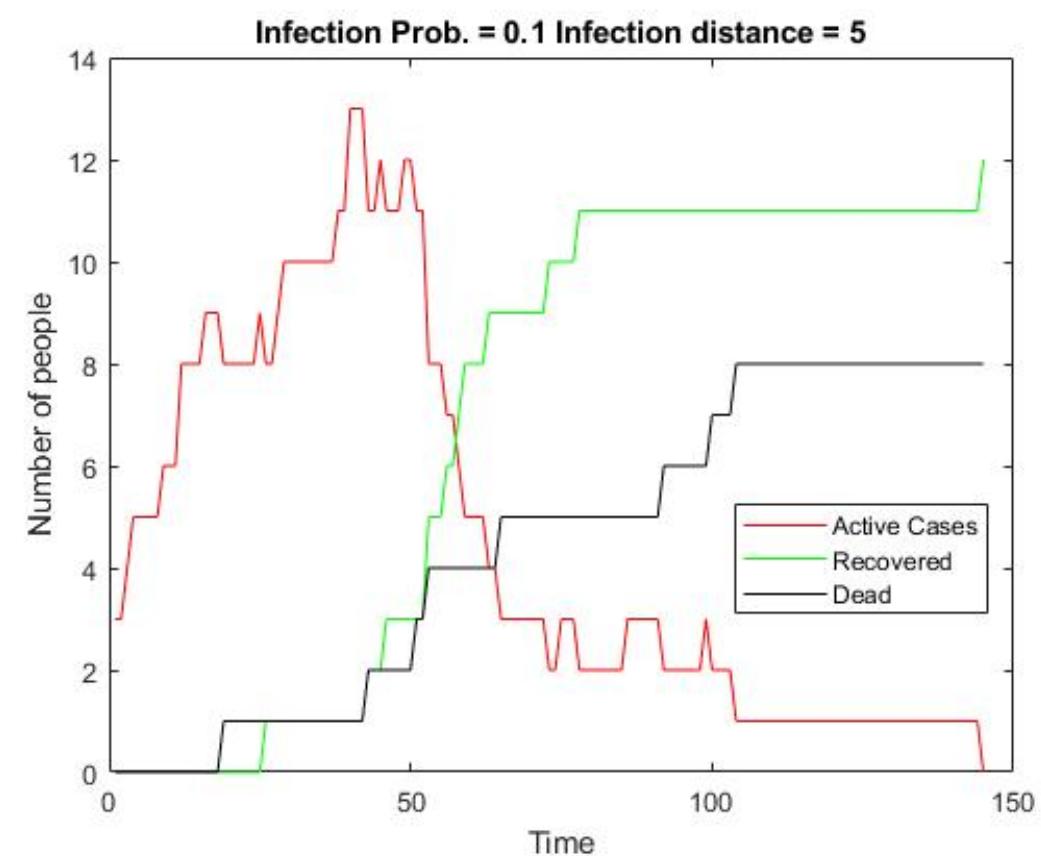


# COMPARISON BETWEEN SPREADS

Higher probability of spread



Reduced probability of spread



# ACCESSIBILITY

- OSU has campus-wide license to full suite
- It is available through OCIO
- MATLAB® is also available on Ohio Supercomputing Center (OSC) through a web-app
- Mathworks provides access to its cloud computing cluster albeit small and most-often slower than desktops

# THANK YOU!

QUESTIONS? COMMENTS?

**Punit Tulpule, PhD**

Research Assistant Professor, Mechanical And Aerospace Engineering (Dept.)

[Simulation Innovation and Modeling Center](#)

[Center for Automotive Research](#)

Smith Laboratory, Room 2132 | 174 West 18th Ave, Columbus, OH 43210

(614) 688-1656 Office | (515) 203-9680 Mobile

Email: [tulpule.3@osu.edu](mailto:tulpule.3@osu.edu)



THE OHIO STATE UNIVERSITY  
COLLEGE OF ENGINEERING

