Zeke:

Python Platform for Teaching Mathematical Modeling of Infectious Disease

SciPy 2014

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Acknowledgements

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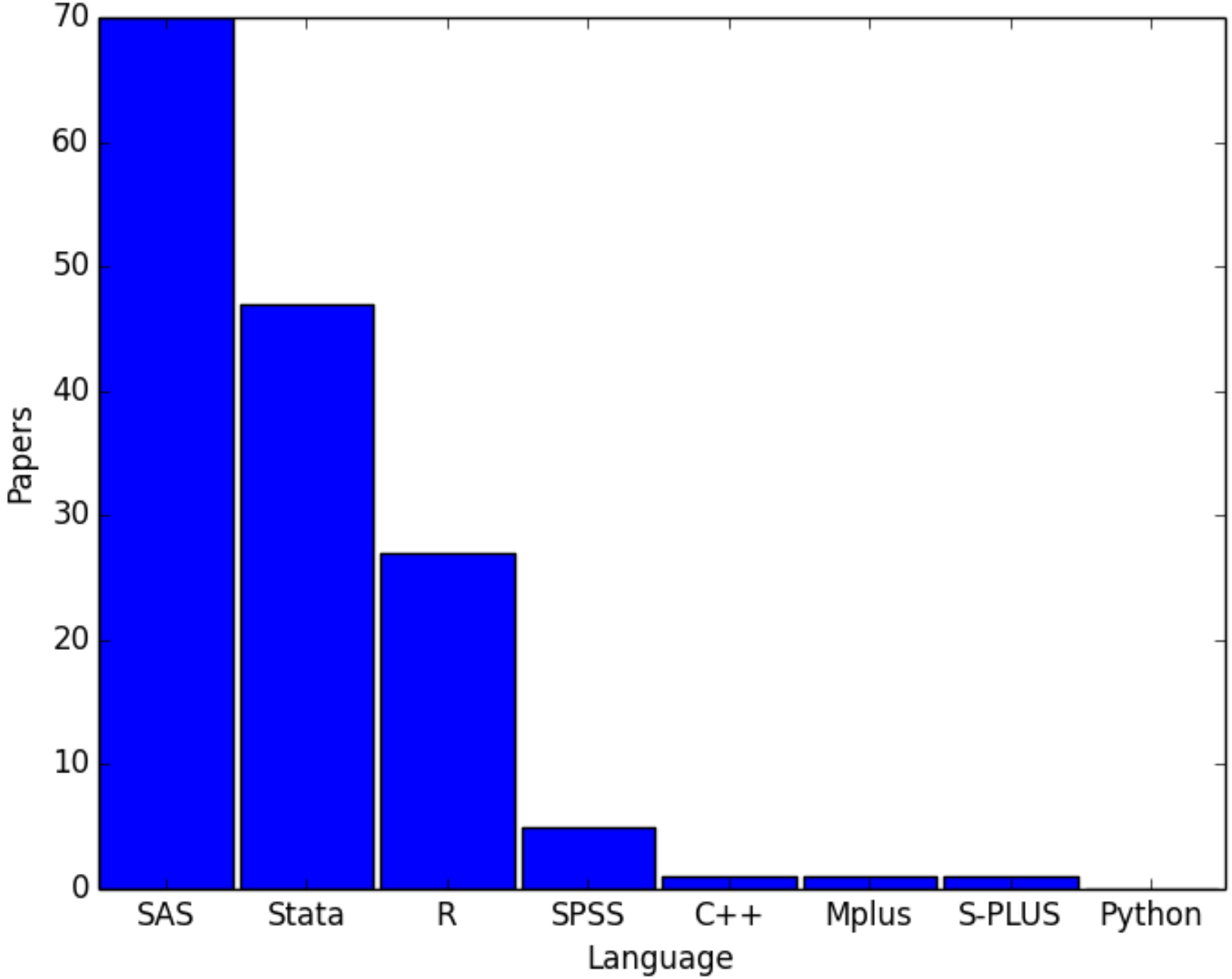
  - Alex Clark (ACLARK.NET)
- Funding:
  - National Institutes of Health and National Institute of General Medical Sciences – Models of Infectious Disease Agent Study Grant 5U01GM070694-11
  - Merck IISP

Background

- Computational Epidemiologist
  - Mostly in Hospital Epidemiology
- Background is from an observational Epidemiology department
  - Lots of stats, less so programming
  - *Zeke* is in many ways retracing my steps


70
60
50
40
30
20
10
0
Papers
SAS
Stata
R
SPSS
C++
Mplus
S-PLUS
Python
Language

A Disclaimer

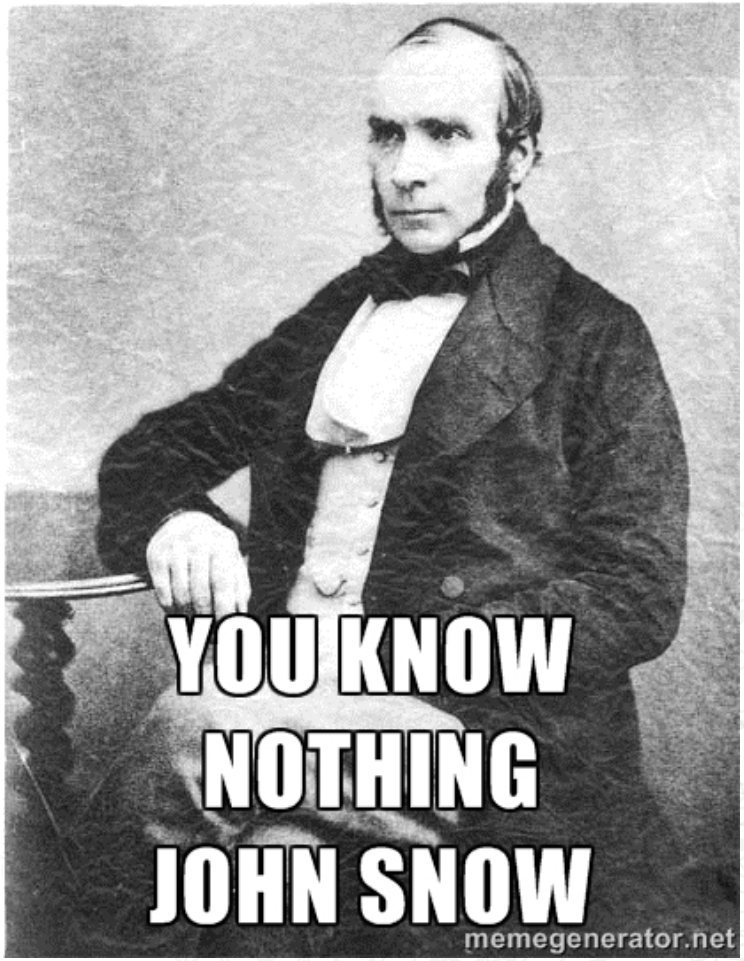
- No brilliant new Python is going to be shown here today

"The goal of *Zeke* is to develop general purpose, transferrable computational science skills. As such, the libraries used should be widely available and in common usage - for example, SciPy for scientific computing functions, and Django as a web front-end, rather than bespoke functions, unless no other option is available."

- ~~`pip install zeke`~~
- ~~`from zeke import *`~~
- Go see Caitlin Rivers talk on Epipy on Thursday

Mathematical Models in Epidemiology

- Modeling is an established discipline in public health
  - Bernoulli in 1760 with Smallpox
  - Modern incarnation in the early 1900's: Ross, Reed, Frost, etc.
- An invaluable tool in modern public health
  - Can illustrate difficult concepts
    - Herd immunity
    - Competing/complementary interventions
  - Quantitative research on difficult, expensive or otherwise infeasible questions
    - Vaccines, pandemic planning, etc.



But How Do We Teach Modeling?

- Public health: Emphasis on interpretation and composition of models
  - Implementation, either analytical or computational, is left as a "black box"
- Math: Emphasis on mathematical analysis of models as dynamical systems problems
- Problems for both:
  - Public health students have only a loose understanding of model implementation and analysis
  - Math students are focused on abstract or mathematically interesting points rather than public health needs
  - Everyone has a two part learning curve, split between programming, theory, and infectious diseases

Comparison to Observational Epi

Observational Epi

- Disease-agnostic general toolkit adapted to specific questions
- Very little subject matter expertise needed to use basic methods
- Solid foundation to extend to more complex approaches

	Exposed	Unexposed
Disease	**A**	**B**
No Disease	**C**	**D**

Mathematical Epi

- Single-use disease specific tools
- Very high levels of subject matter expertise required to design a useful model
- Models are frequently borrowed, adapted or modified, often incorrectly
- "Malaria is like Dengue is like Yellow Fever is like hospital-acquired MRSA"

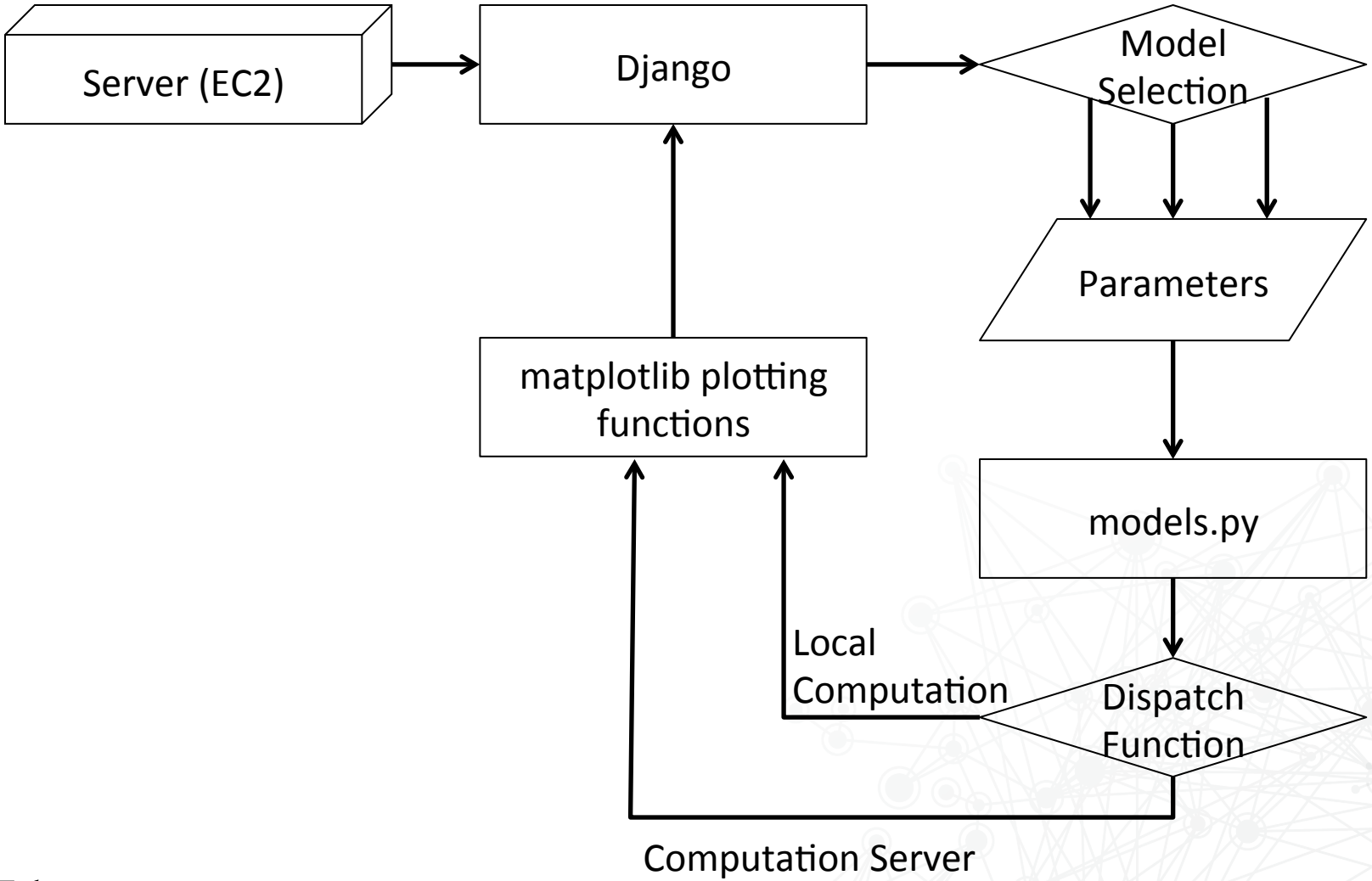
Zombies

Why Zombies?

- Familiar, flexible disease system
  - You can become an "expert" with a night of movies
  - Can change model *forms* without changing *parameters*
  - Lots of room exploring model decision making
    - Interventions, fast vs. slow, latent periods, vectors, etc.

Zeke

- Web-based epidemic modeling interface
  - Hides code unless code is of interest
- Separates disease knowledge, programming skill and theoretical skills development
- As much as possible, models, infrastructure and interface are kept separate
  - Models especially are kept separate

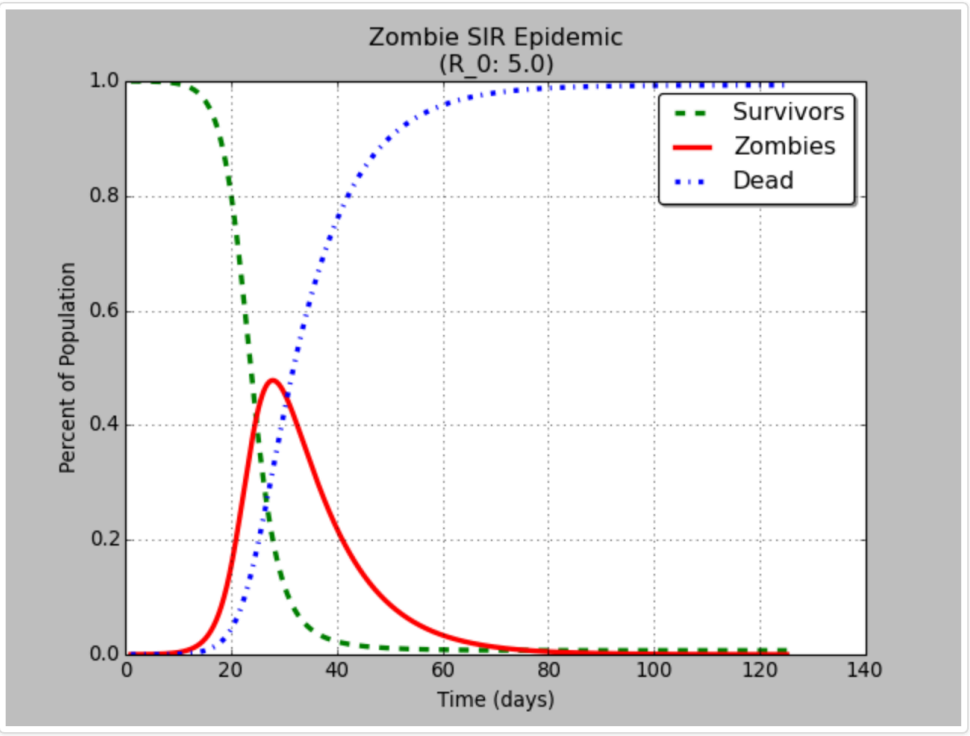

Server (EC2)
Django
Model Selection
Parameters
models.py
Dispatch Function
Local Computation
matplotlib plotting functions
Computation Server

Demo

Zeke About Contact Sign in

Select a model

SIR



Controls

Susceptible-Zombie-Dead mathematical model. Takes two arguments:

- Beta: Contact rate
- Gamma: Infection duration in days

Beta 0.5

Gamma 0.1

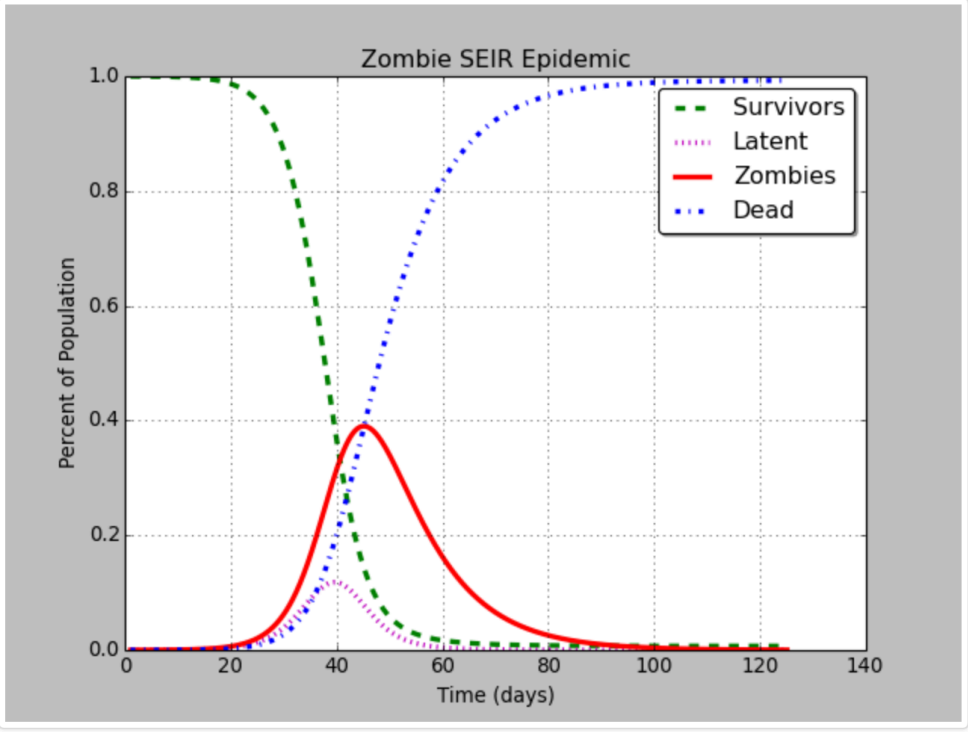
Set values

Reset

Zeke About Contact Sign in

Select a model

SEIR



Controls

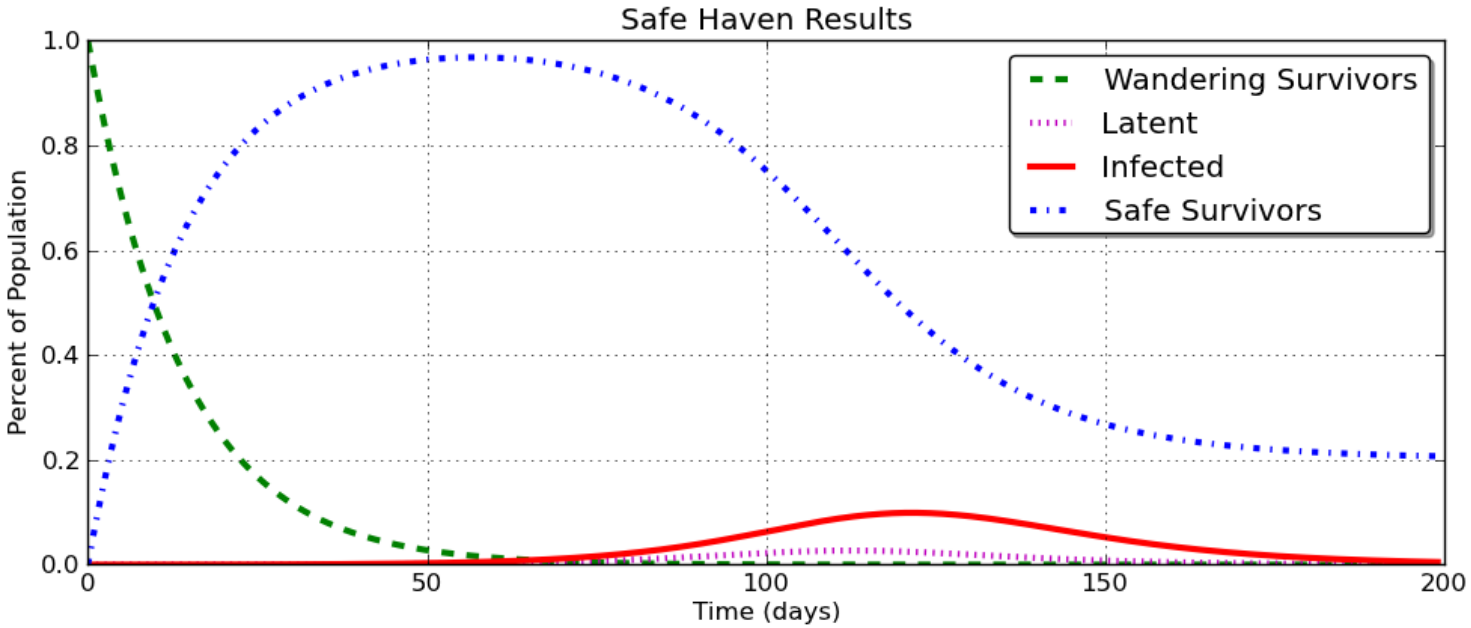
Zombie epidemic model with latent infection period. Takes three arguments:

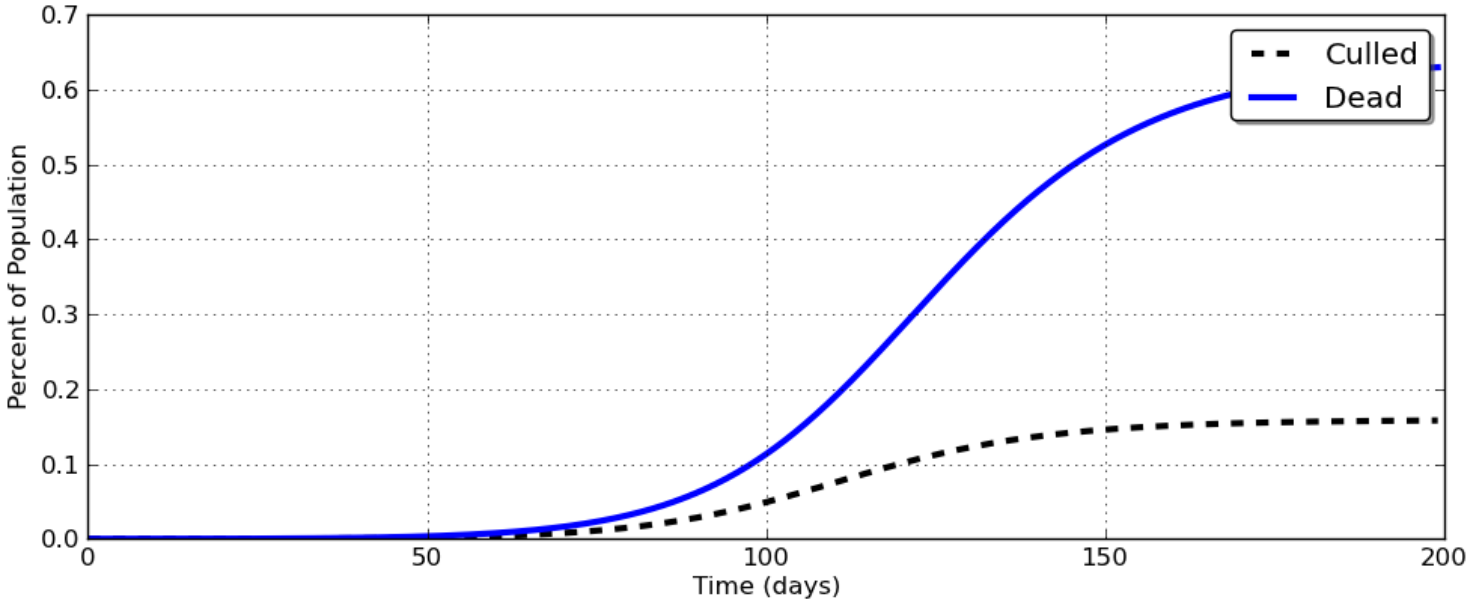
- Beta: Contact rate
- Gamma: Infection duration in days
- Alpha: A latent (non-zombie infected) period in days

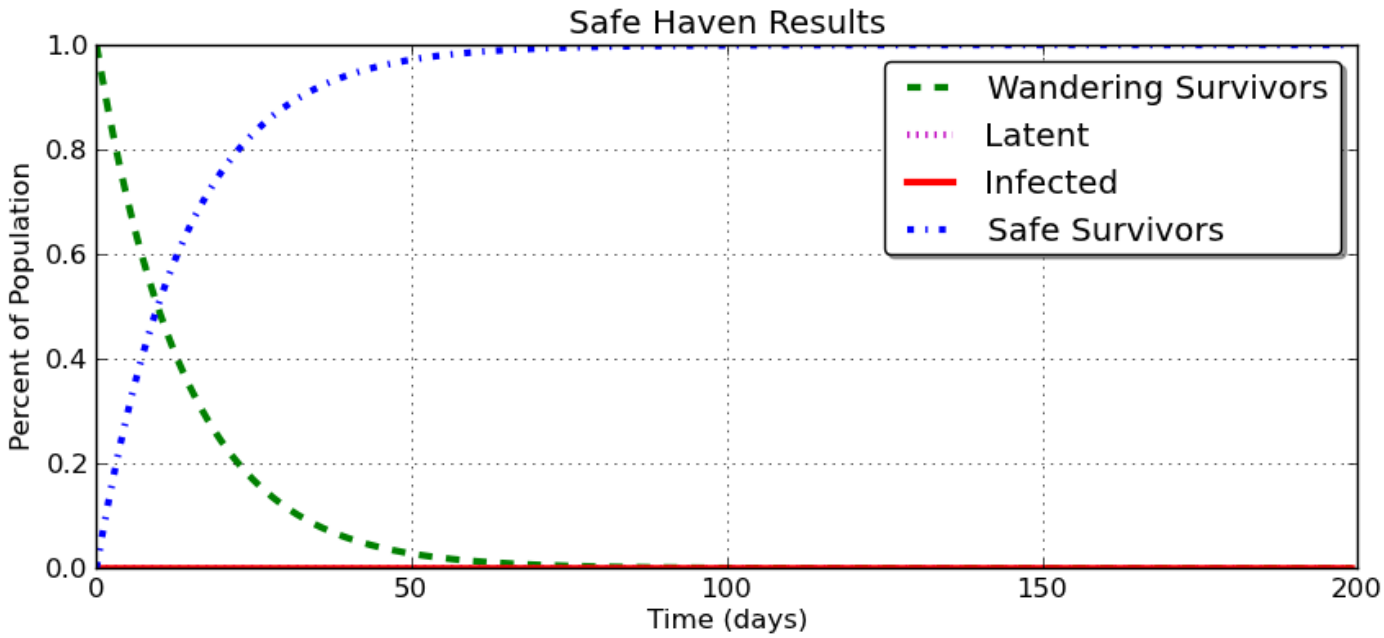
Beta	0.5
Gamma	0.1
Alpha	0.5

Set values

Reset


Safe Haven Results
Wandering Survivors
Latent
Infected
Safe Survivors
Percent of Population
Time (days)
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
200


Culled
Dead
Percent of Population
Time (days)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
50
100
150
200


Safe Haven Results
Wandering Survivors
Latent
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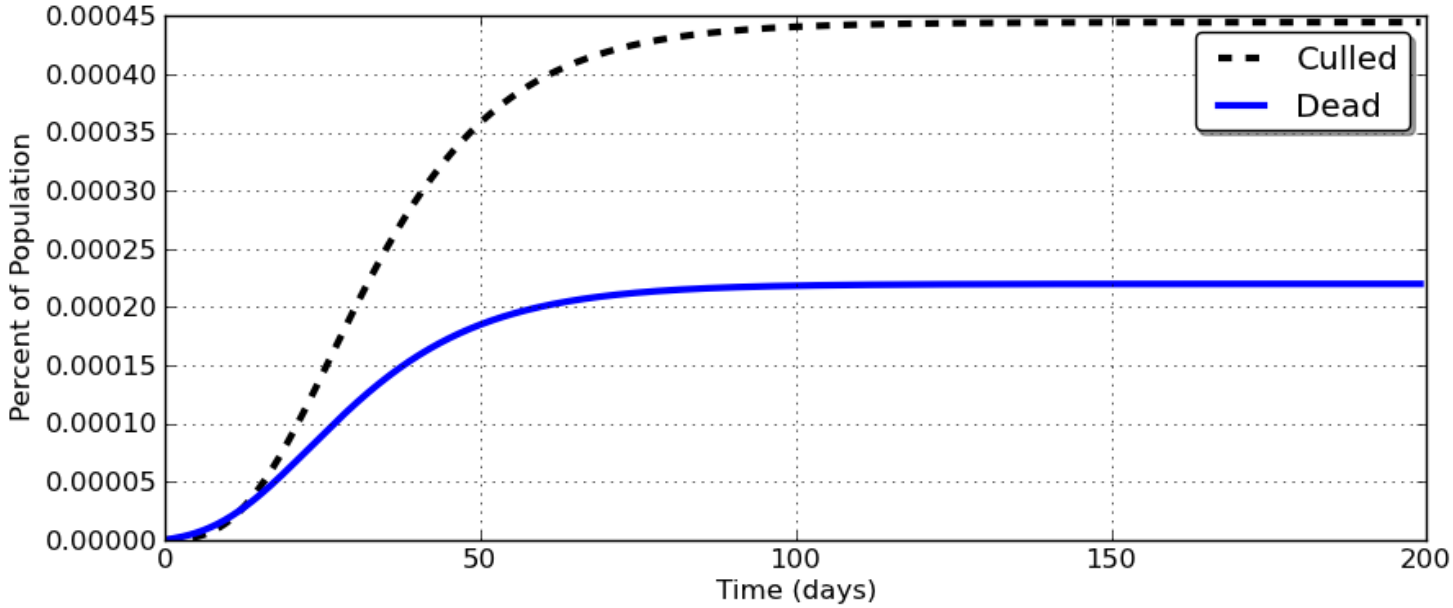
Percent of Population
Time (days)
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
200


Culled
Dead
Percent of Population
Time (days)
0.00000
0.00005
0.00010
0.00015
0.00020
0.00025
0.00030
0.00035
0.00040
0.00045
0
50
100
150
200

Future Directions

- **More Models**
  - Stochastic models
  - Curve fitting
  - Network or agent-based models
- Documentation and Testing
- Adaptation as a web-based modeling framework for non-technical users
  - Different fields: Epidemiology, Ecology, etc.
  - "My computer doesn't work with Doodle"

Contributing

- Always looking for contributors
  - Also meant to be an approachable project for new open source contributors
  - Nice part about keeping things separate: only work on the bits you want
- github.com/epimodels/zeke
- Currently a live deployment at:
  - www.zeke-project.org

Thank You

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- Twitter: @GermsAndNumbers
- GitHub:
  - github.com/epimodels/zeke
  - github.com/elofgren/zombies