Ordinary Differential Equations

as an alternative to agent-based modelling

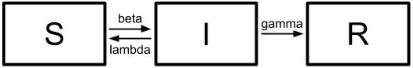
Module

June 18, 2019

ODE systems

The ODE framework

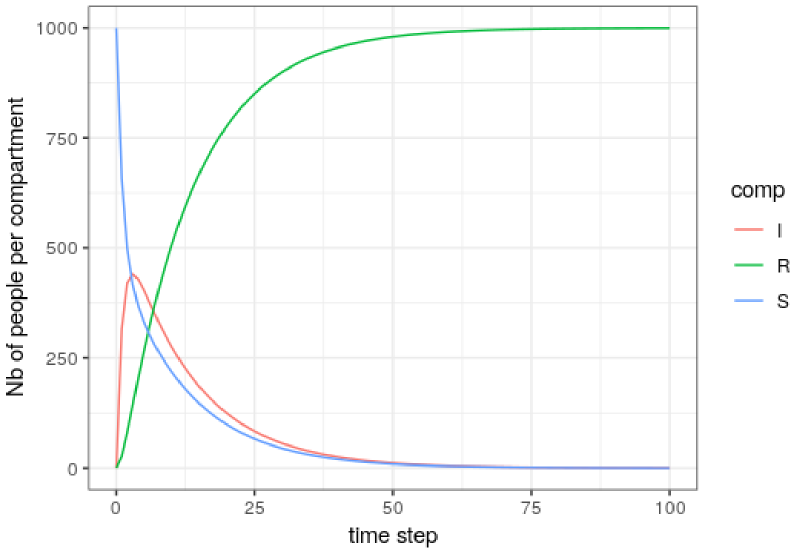
$\rightarrow$ widely used to model transmission phenomena



- population split into compartments
- system of ordinary differential equations

$$
\begin{cases}
\dfrac{\mathrm{d}S}{\mathrm{d}t} & = & -\beta S + \lambda I \\[2ex]
\dfrac{\mathrm{d}I}{\mathrm{d}t} & = & \beta S - (\lambda + \gamma) I \\[2ex]
\dfrac{\mathrm{d}R}{\mathrm{d}t} & = & \gamma I
\end{cases}
$$

SIR model dynamics



ODE	ABM
Equation-based	Individual-based
Generic mechanisms	Precise mechanisms
Population scale	Individual scale
Needs less resources	Computationally expensive

A Zombie situation

How could we model the Zombie invasion?

- Which mechanisms?
- Which parameters?

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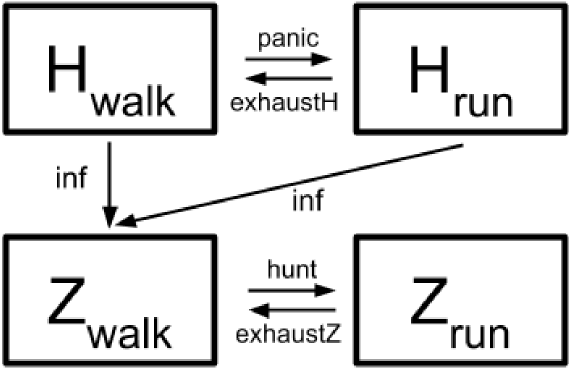
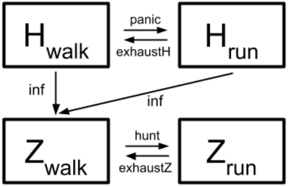
- Which mechanisms?
- Which parameters?

How can we assess our model's ability to reproduce the real data?

- Which metrics?
- Which fitness function?

A very simple ODE model





$$
\begin{cases}
\dfrac{\mathrm{d}H_{walk}}{\mathrm{d}t} = -(panic + inf) * H_{walk} + exhaustH * H_{run} \\
\dfrac{\mathrm{d}H_{run}}{\mathrm{d}t} = panic * H_{walk} - (exhaustH + inf) * H_{run} \\
\dfrac{\mathrm{d}Z_{walk}}{\mathrm{d}t} = inf * (H_{walk} + H_{run}) - hunt * Z_{walk} + exhaustZ * Z_{run} \\
\dfrac{\mathrm{d}Z_{run}}{\mathrm{d}t} = hunt * Z_{walk} - exhaustZ * Z_{run}
\end{cases}
$$

Exploration

First step: Calibrate

We have some real time series of zombie invasion
$\rightarrow$ find the parameter values to best fit them

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Process

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Process

- Embed the model in OpenMOLE

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Process

- Embed the model in OpenMOLE
- Define a fitness function

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Process

- Embed the model in OpenMOLE
- Define a fitness function
- Write a calibration task

Parameter set

Second step: Profiles

Adding complexity

New mechanisms

OpenMOLE

What mechanisms could we add to better represent the complexity of our Zombie situation?

Study our model's parcimony