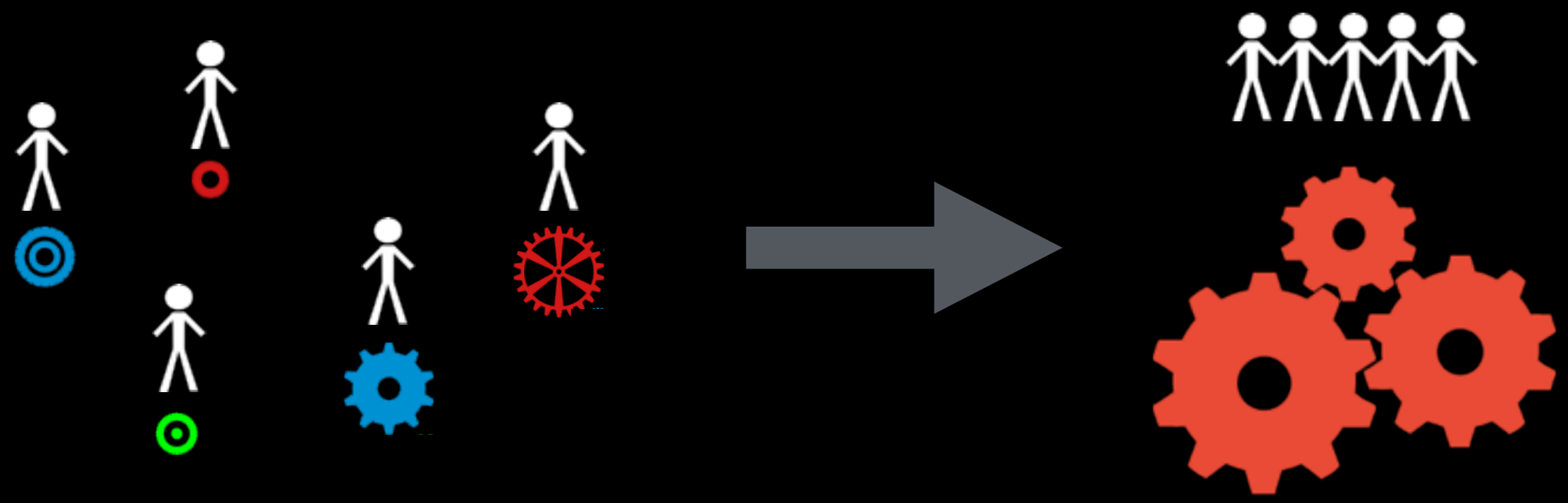
S|S|M

Inference for State Space Models

Modelling complex & dynamic quantities:

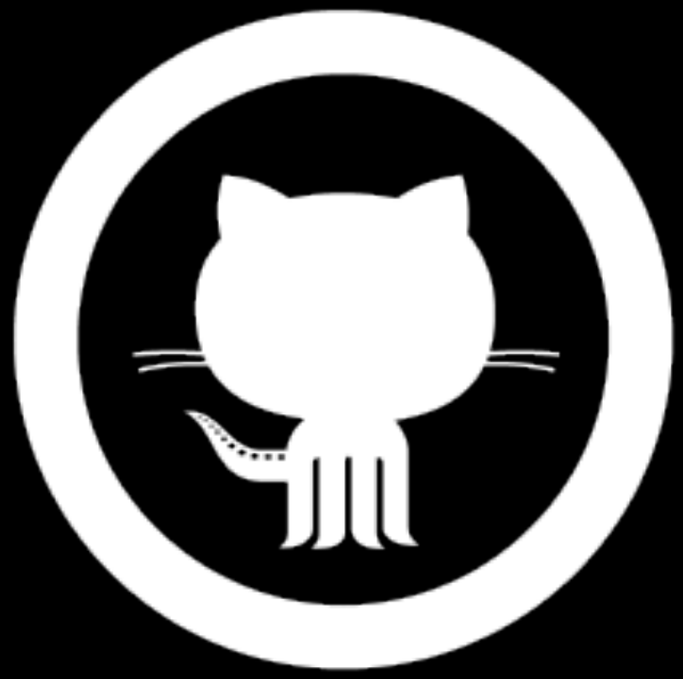
reorganising to meet up with technical challenges.



https://github.com/standard-analytics/ssm

Open Source community

+ you



Sign up for GitHub

https://github.com/

WHY?

Question?
Raise issues

Support!

Keep informed

Objectives 5x3 hours

Build your own compartmental models

Calibrate them against simple and complex data

Study an open problem in epidemiology

Step 0

Is SSM properly installed on your machines?

In your terminal: `> ssm -V`

Step 1

Build simple models.

Simulate deterministic and stochastic scenarios from them.

SIR First steps

change directory

```
> cd examples/sir
> ls
```

list content

package.json???

JSON: JavaScript Object Notation

JSON

double-quotes only!

Lists: `[ ‘‘a’’, 3, … ]`

Objects: `{ ‘‘a’’: ‘‘A’’, ‘‘b’’: 3, …}`

Flexible, readable format.

Popular open standard.

package.json

Used to distribute code & data through the node package manager (npm)

Standard keys:

```
“name”, “description”, “keywords”,
“licenses”, “version”, “resources”
```

npm

```
npm install <name>
…
npm publish
```

Seamlessly keep track of your work and distribute it.

SIR Let’s get to it

Closer look at the “model” object.

SIR Simulation

```
> ssm install package.json
> cd bin
> ./simul --help
> cat ../package.json | ./simul --hat
```

→ hat_0.csv

SIR Plot hat_0.csv

Open TD.R in R

!!! Set TD-STRU to be Working Directory

Plot hat_0.csv with ssm.plot.hat

SIR Explore

Explore different values of R0 and d

Under which minimal conditions does an epidemic burst?

SI Make your own model

Duplicate and rename SIR.
Modify it to obtain an SI model.

According to the SI model, what will be the number of susceptibles on December 13th, 2012?

How does it compare to an SIR model?
What about an SIRS model?

SIRS Little harder

Duplicate and rename SIR.
Modify it to obtain an SIRS model.

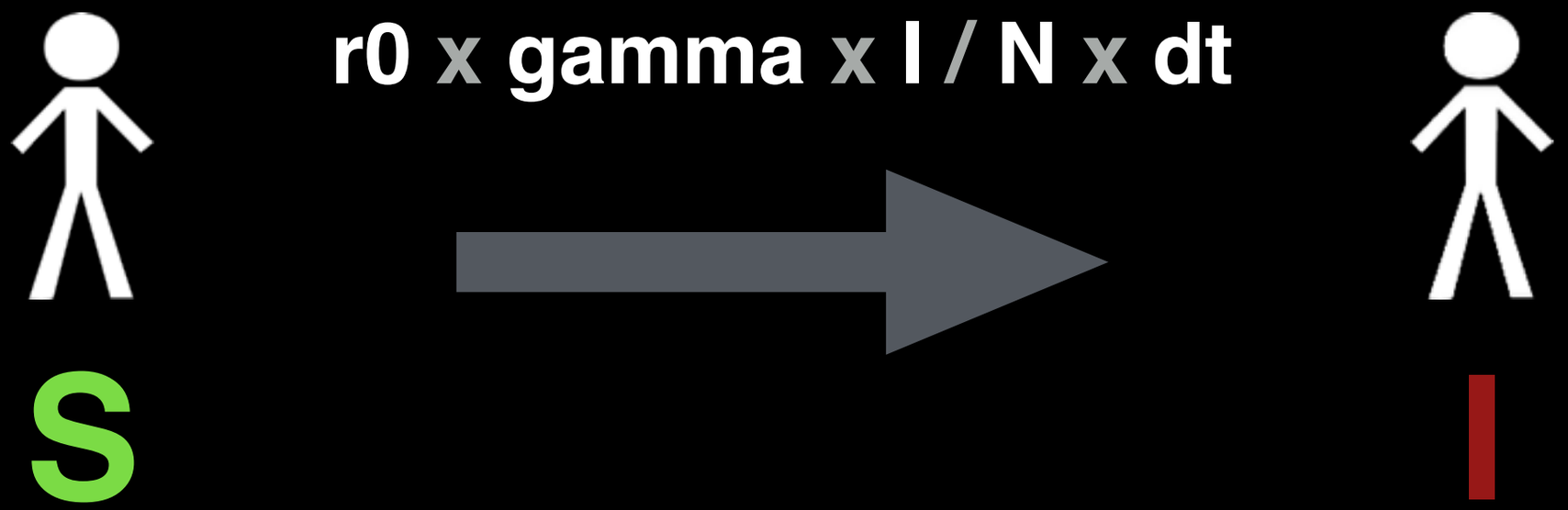
So, what about December 13th, 2012?
Why?

Ok, but...

Aren’t these deterministic scenarios a bit too simplistic?

Noise Poisson process formalism

For every individual:



infection is a random process

Noise Poisson process formalism

For S_t individuals:

$$p(\text{n infections}) \approx \binom{S_t}{n} \mathbf{r0 \times gamma \times I / N \times dt}$$

→ tractable stochastic model

For more details, see: Breto et al (2009). *Time series analysis for mechanistic models.*

Noise SDE formalism

Going further, following Ethier & Kurtz 1986:

dSt = - r0 x gamma x I / N x St dt - sqrt(r0 x gamma x I / N x St) dBt

dIt = r0 x gamma x I / N x St dt + sqrt(r0 x gamma x I / N x St) dBt

→ *Diffusion approximation*

For more details, see: Dargatz (2007). *A diffusion approximation for an epidemic model.*

To remember

psr best tractable approximation

sde continuous approximation
classical mathematical object
theory only for large populations

SIR Let's try with noise

Number of particles

```
> cat ../package.json | ./simul psr --hat -J 1000
```

```
> cat ../package.json | ./simul psr --hat -J 1000 -I 1
```

Run id

Plot and compare hat_0.csv and hat_1.csv

Try with a 1000 inhabitants population (re-install model)