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Flexible Synthetic Data Generation with library(tidysynthesis)

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2. Synthetic data are only as good as the synthesizer.
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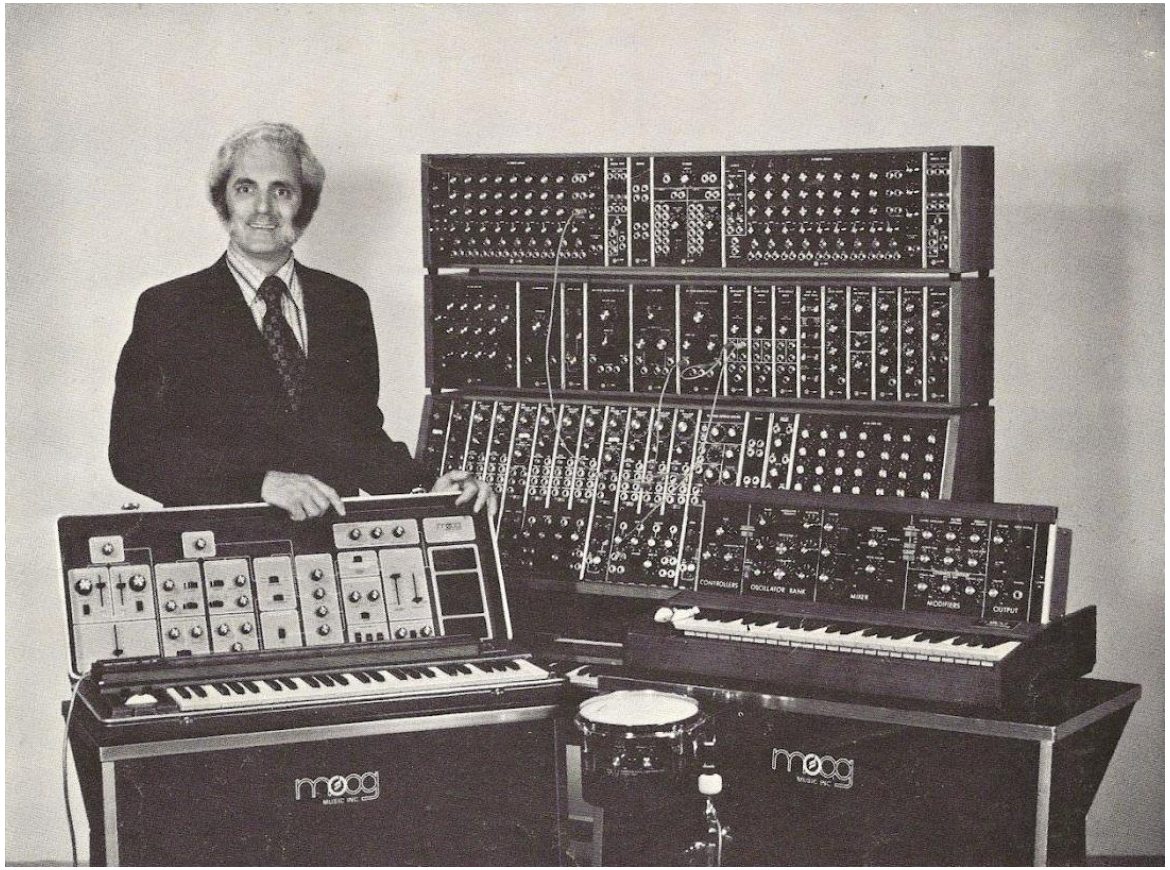
4. library(tidysynthesis) is modular, extensible, and builds on library(tidymodels).
5. This works well for generating select synthetic data.

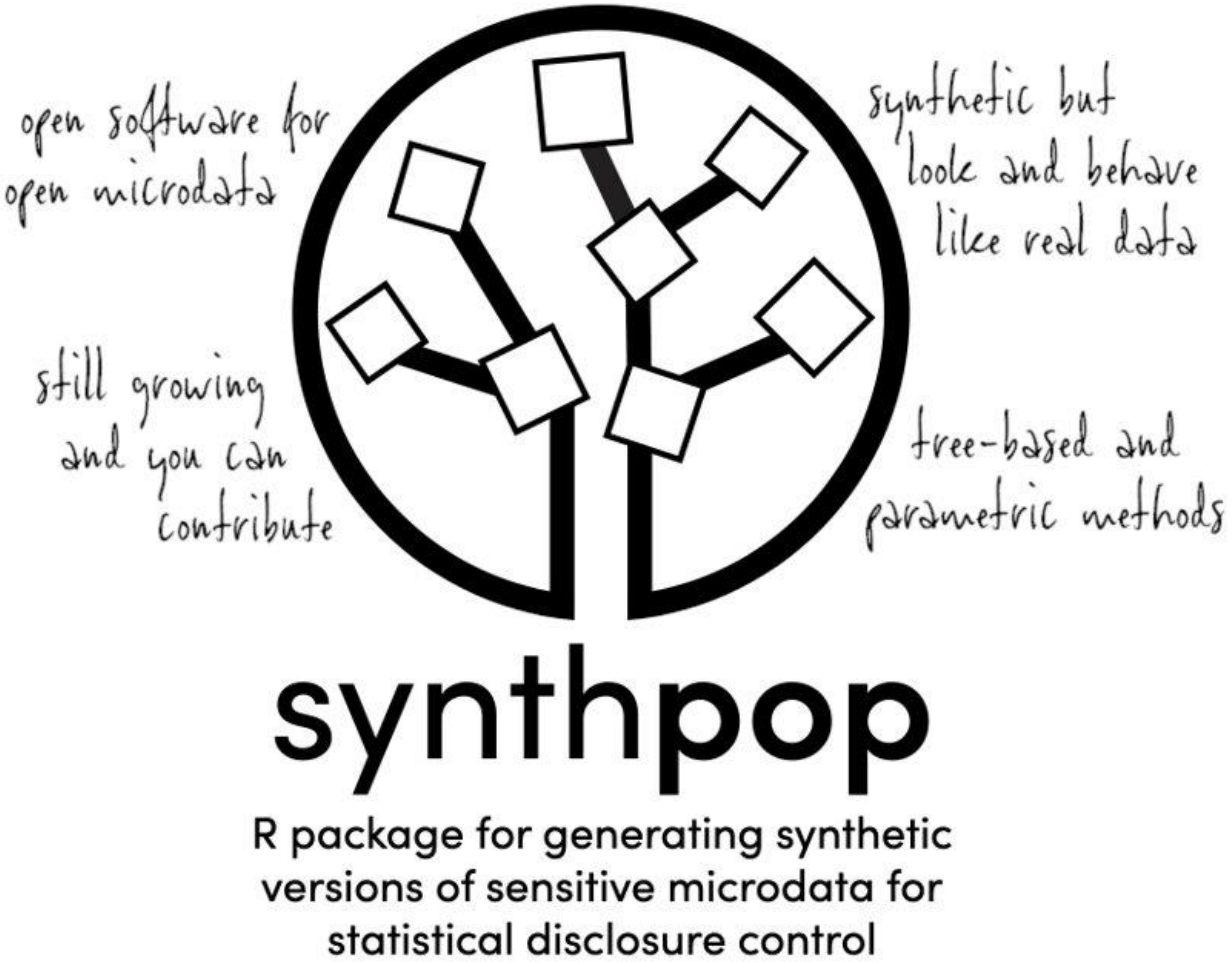
Build a Synthesizer

- Protects the confidentiality of individual information.
- Uses a fully conditional specification to model the joint multivariate distribution.



Existing Functionality is Groundbreaking, but Limited

- Limited to a small set of methods
- Difficult to extend



R Packages

- **tidysynthesis:** Flexible tools for generating fully and partially synthetic data.
- **syntheval:** Utility and disclosure risk evaluation of synthetic data.

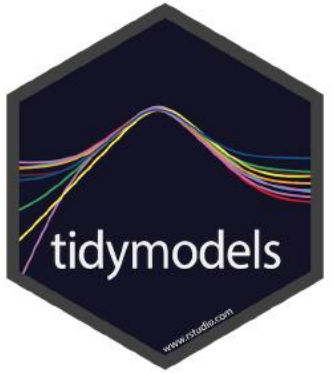
Our Approach

1. Embrace design philosophy from tidyverse and tidymodels 

2. Flexible
3. Modular
4. Extensible

library(tidymodels)

- *All the power of library(tidymodels) for data synthesis, concisely, with a few special tools.*



- Full predictive modeling toolkit

Flexibility

- Express different recipes, predictive models, and samplers for each variable
- Hyperparameter tuning
- Additional noise
- Mid-synthesis constraints
- Synthesize missing data
- Parallel computation with futures/furrr

Modular

- Everything is handled through objects with classes
  - Interchangeable objects that act like building blocks
- Robust testing suite
- Manage computation
  - Lazy evaluation and checks that catch errors before computation

Extensibility

- Ability for someone else to add the thing we haven't thought of

Demonstration

Synthetic data

Confidential data

select	species	island	sex	bill_length_mm	…
TRUE	Adelie	Torgersen	male	39.1	…
FALSE	Adelie	Torgersen	female	39.5	…

Synthetic data

select	species	island	sex	bill_length_mm	…
TRUE					
TRUE					


Synthetic data!

Synthetic data

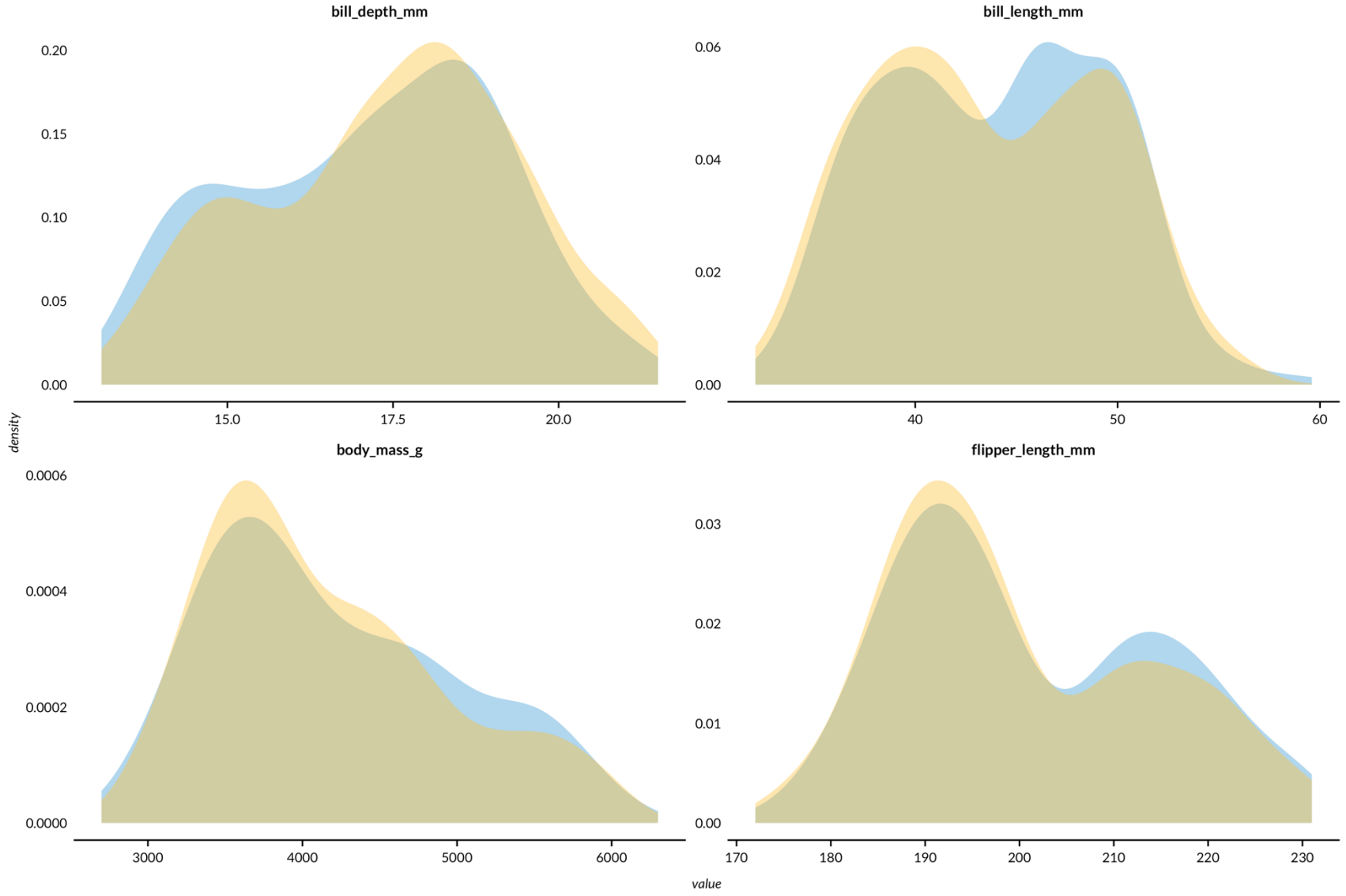
Confidential data

select	species	island	sex	bill_length_mm	…
TRUE	Adelie	Torgersen	male	39.1	…
FALSE	Adelie	Torgersen	female	39.5	…

Synthetic data

select	species	island	sex	bill_length_mm	…
TRUE	Chinstrap	Dream	male	48.4	…
TRUE	Gentoo	Biscoe	male	51.4	…

The Synthetic Data are Similar to the Confidential Data



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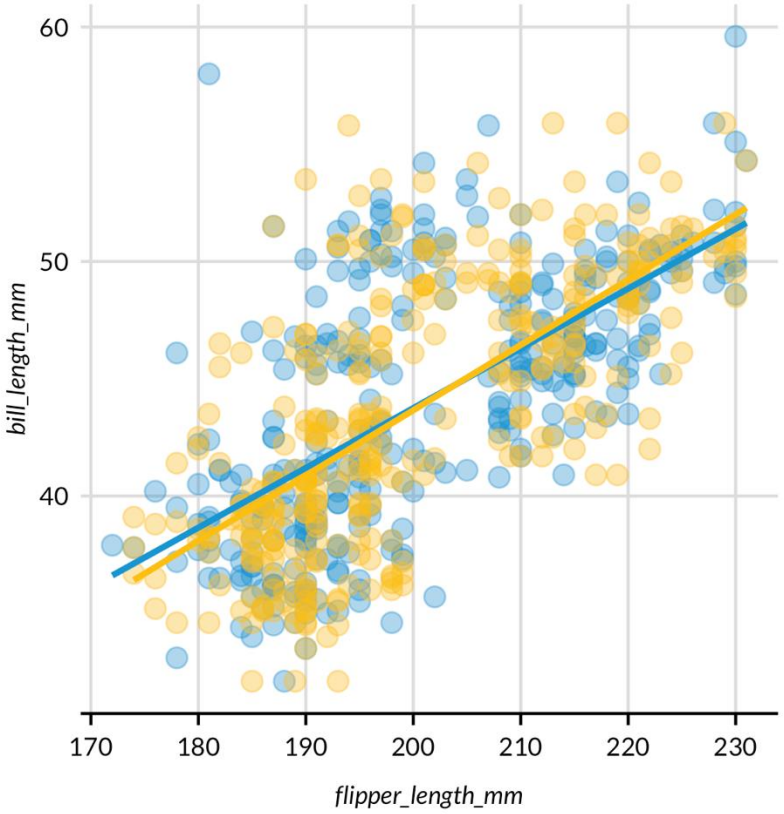

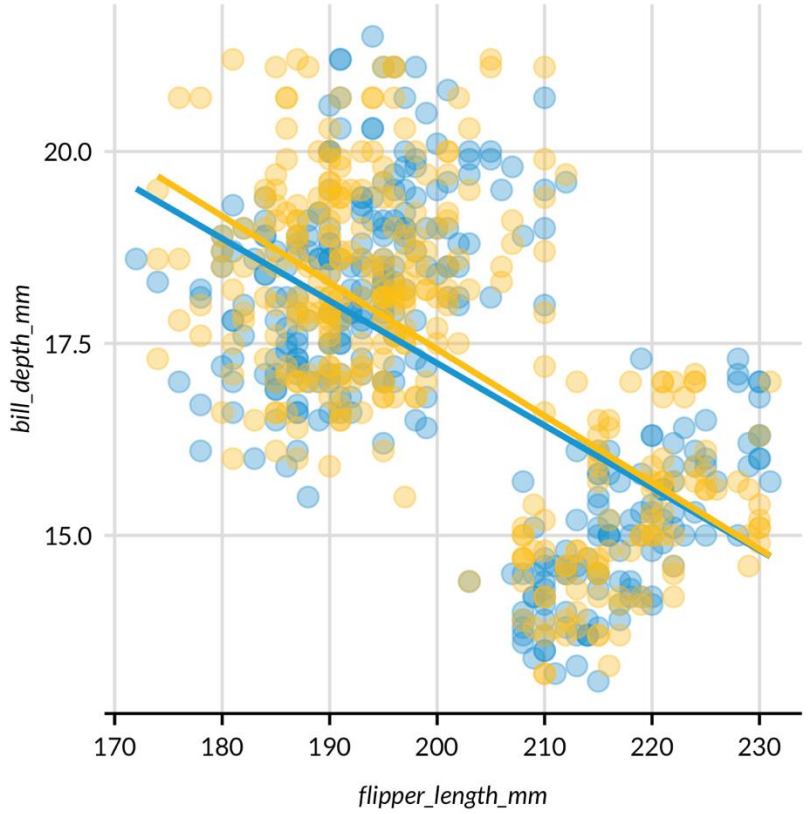

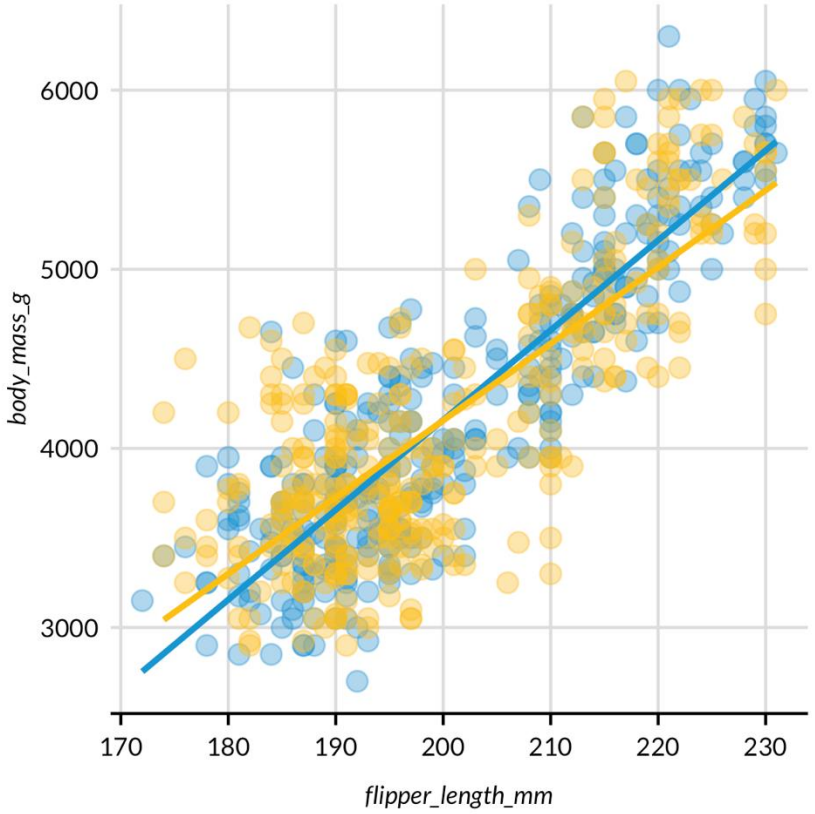

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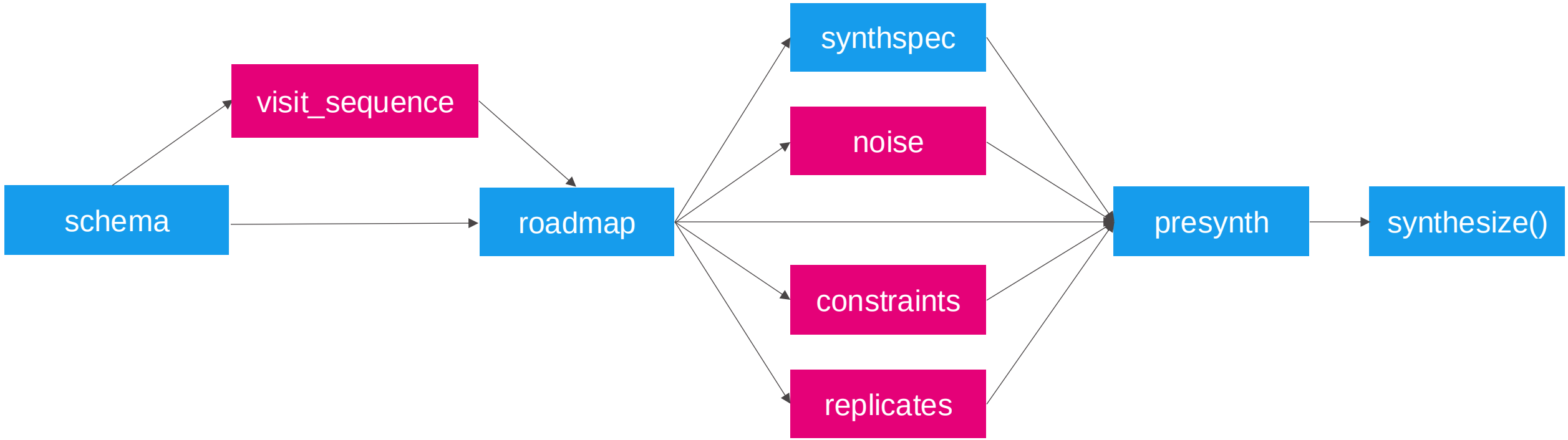
Workflow


synthspec
visit_sequence
noise
schema
roadmap
presynth
synthesize()
constraints
replicates

Estimating the multivariate distribution of the data

- Goal is to approximate the empirical multivariate distribution function for the data
- Joint multivariate probability distribution can be represented as the product of sequential, conditional probability distributions:

$$f(\mathrm{Y}_1, \mathrm{Y}_2, \ldots, \mathrm{Y}_k \,|\theta_1, \theta_2, \ldots, \theta_k) \;=$$

$$f_1(Y_1 \mid \theta_1) \cdot f_2(Y_2 \mid Y_1, \theta_2) \cdots f_{\mathrm{k}}(Y_k \mid Y_1, Y_2, \ldots, Y_{k-1}, \theta_k)$$

  - where Y_i the variables and θ_i are vectors of model parameters