Accelerating Access to Life-Saving Treatments to Patients

pumas AI

Augmenting healthcare intelligence with predictive analytics that turn data into life-saving decisions

Our data-analytical tools help make data-driven decisions more efficiently

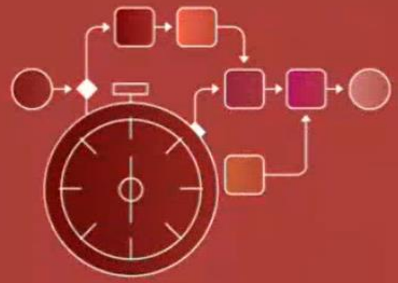
PumasCP

DeepPumas

Pumas

We humanize technology to provide personalized treatments for patients

Lyv



Find the shortest development path for regulatory approval, with us

Scientific &
Strategic Consulting

pumas AI

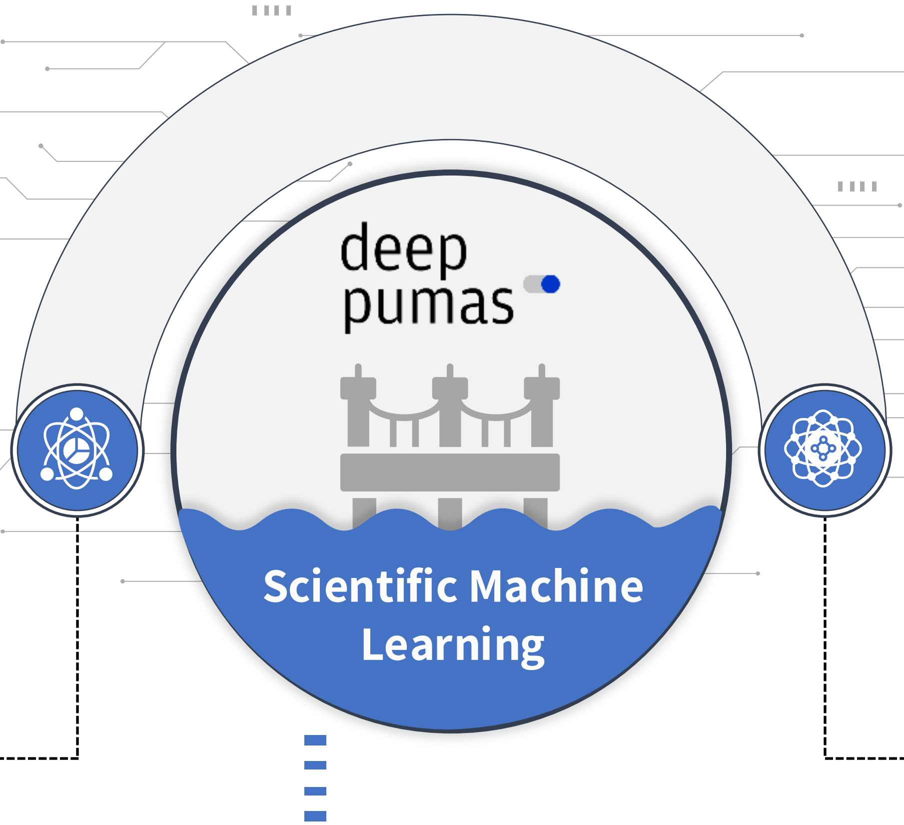
DeepPumas Introduction

Niklas Korsbo

Machine Learning

- Automatic model discovery
- Finding unintuitive relationships
- Handling complex data

- Lacks scientific understanding
- Requires big data
- Inscrutable



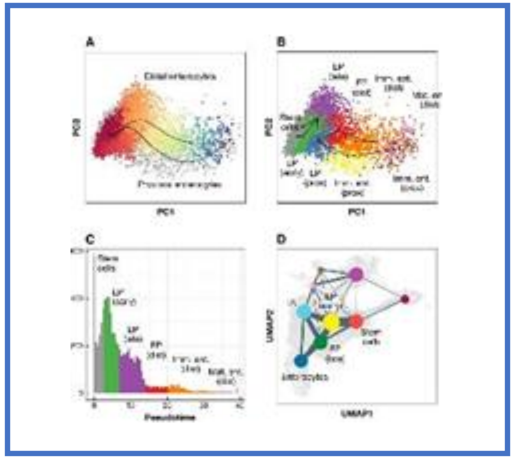
Scientific Modeling

- Encoding scientific understanding
- Encoding information hierarchies
- Data-efficient
- Transparent and interpretable
- Dosage optimization, etc.

- Labor intensive
- Misses unintuitive relationships
- Hard to utilize complex data

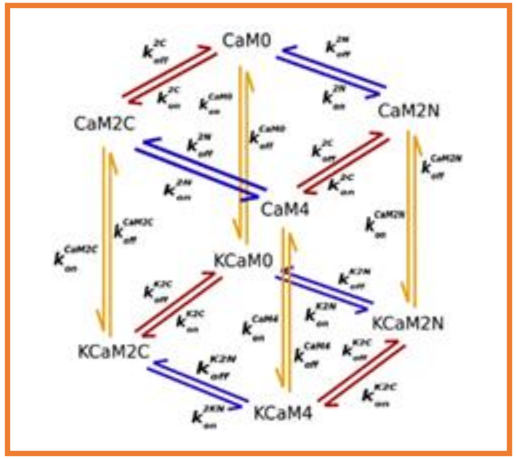
DeepPumas – simple and effective utilization of both knowledge and data

Data



Good Predictions

Models



Clinical Tests

Medical Images

Measured Outcomes

Monitoring Devices

Omics

Wearables

- Known Molecular Interactions
- Known Cell Interactions
- Known Drug Properties
- Known Prognostic Factors

Lead Generation » **Clinical Research** » **Market Research** » **Quality-by-design Manufacturing** » **Individualized Patient Management**

NLME

Typical values

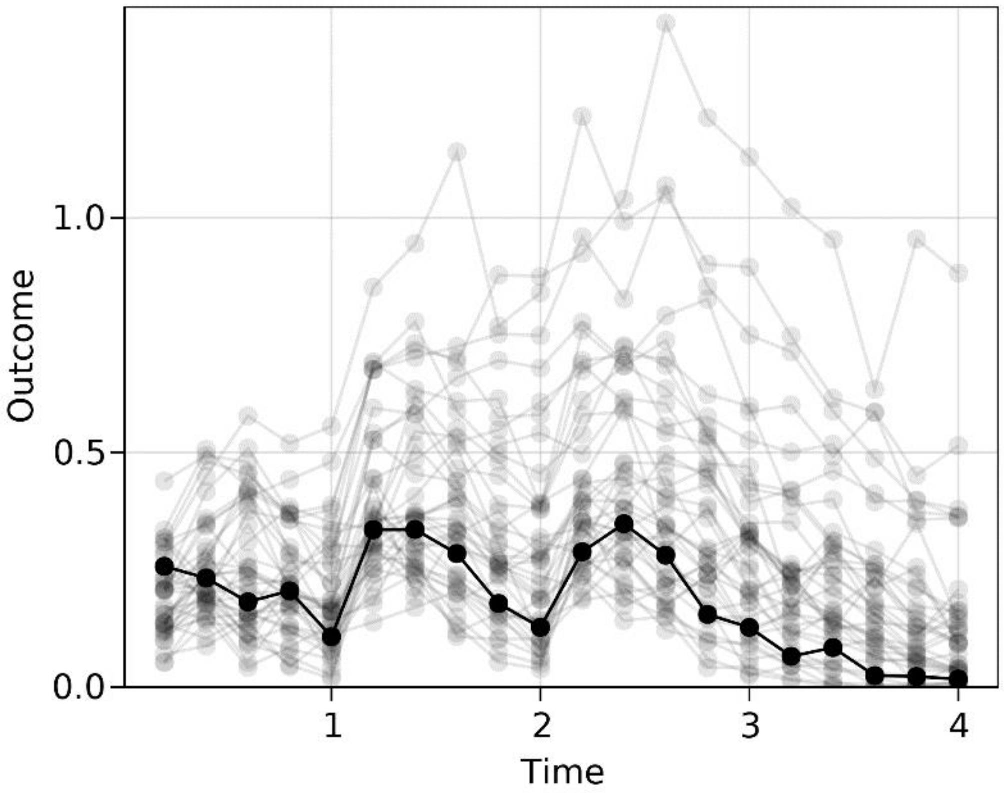
$$\theta \in \mathbb{R}^3_+$$
$$\Omega \in \mathbb{R}^3_+$$

Patient data

Age
Weight

Random effects

$$\eta \sim \mathrm{MvNormal}(\Omega)$$



Individual parameters

$$\begin{aligned} Ka_i &= \boldsymbol{\theta_1} \cdot \boldsymbol{e^{\eta_{i,1}}} + c_1 \cdot Age_i \\ CL_i &= \boldsymbol{\theta_2} \cdot \boldsymbol{e^{\eta_{i,2}}} \\ V_i &= \boldsymbol{\theta_3} \cdot \boldsymbol{e^{\eta_{i,3}}} + c_2 \cdot Weight_1^{c_3} \end{aligned}$$

Dynamics

$$\begin{aligned} \frac{d[\mathrm{Depot}]}{dt} &= -Ka[\mathrm{Depot}], \\ \frac{d[\mathrm{Central}]}{dt} &= Ka[\mathrm{Depot}] - \frac{CL}{V}[\mathrm{Central}]. \end{aligned}$$

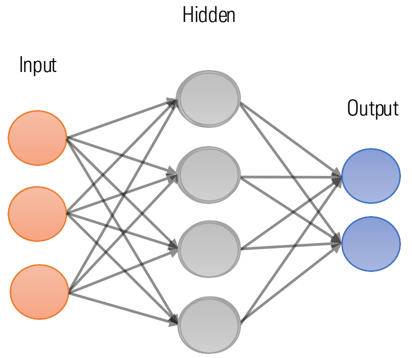
Error model

$$Outcome \sim \mathrm{Normal}\left(Central, \sqrt{Central} \cdot \sigma\right)$$

WHAT IS A NEURAL NETWORK (NN)?

Information processing mechanism

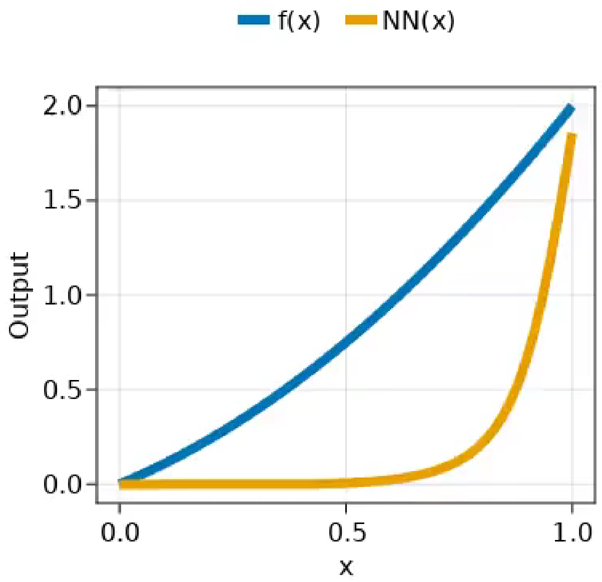
Loosely based on neurons



Mathematically: Just a function!

NNs are useable anywhere where you'd use a function!

Universal approximators!



- Approximate <u>any</u> function
- Functional form tuned by parameters
- Parameter tuning can be linked to observed patient outcomes

Use **data** to automatically discover **relationships**

NLME WITH DEEPPUMAS

Typical values

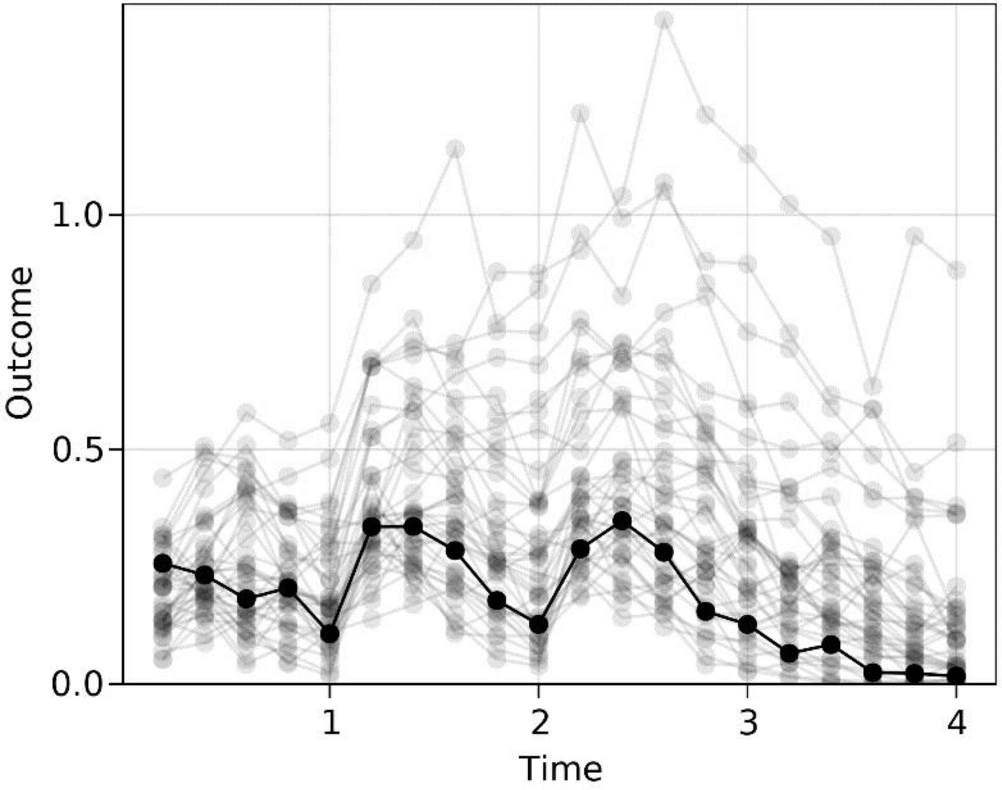
$$\theta \in \mathbb{R}^3_+$$
$$\Omega \in \mathbb{R}^3_+$$

Patient data

Age
Weight

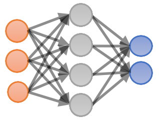
Random effects

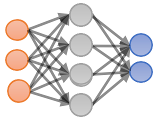
$$\eta \sim \mathrm{MvNormal}\,(\Omega)$$



Individual parameters

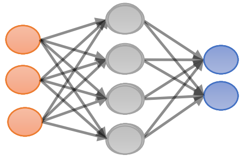
$$\begin{aligned} Ka_i &= \theta_1 \cdot e^{\eta_{i,1}} + c_1 \cdot Age_i \quad + \\ CL_i &= \theta_2 \cdot e^{\eta_{i,2}} \\ V_i &= \theta_3 \cdot e^{\eta_{i,3}} + c_2 \cdot Weight_1^{c_3} \quad + \end{aligned}$$





Dynamics

$$\frac{d[\mathrm{Depot}]}{dt} = -Ka[\mathrm{Depot}],$$
$$\frac{d[\mathrm{Central}]}{dt} = Ka[\mathrm{Depot}] -$$



Error model

$$Outcome \sim \mathrm{Normal}\left(Central, \sqrt{Central} \cdot \sigma\right)$$

DeepNLME – Flexible local information processing

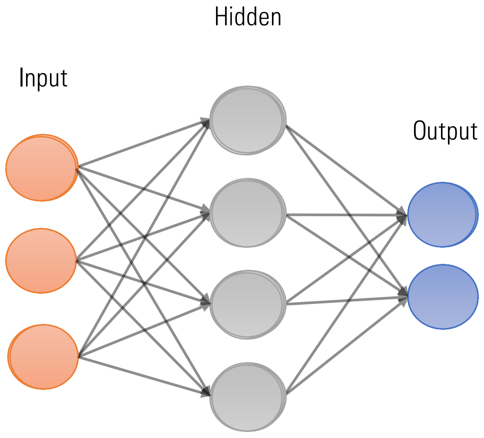
Covariate data

Dynamic variables

Random effects

Time

Drug PK

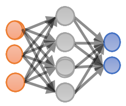


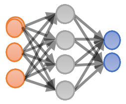
Individualized parameters

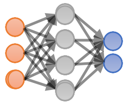
Outcome transformations

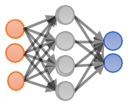
Longitudinal biomarkers

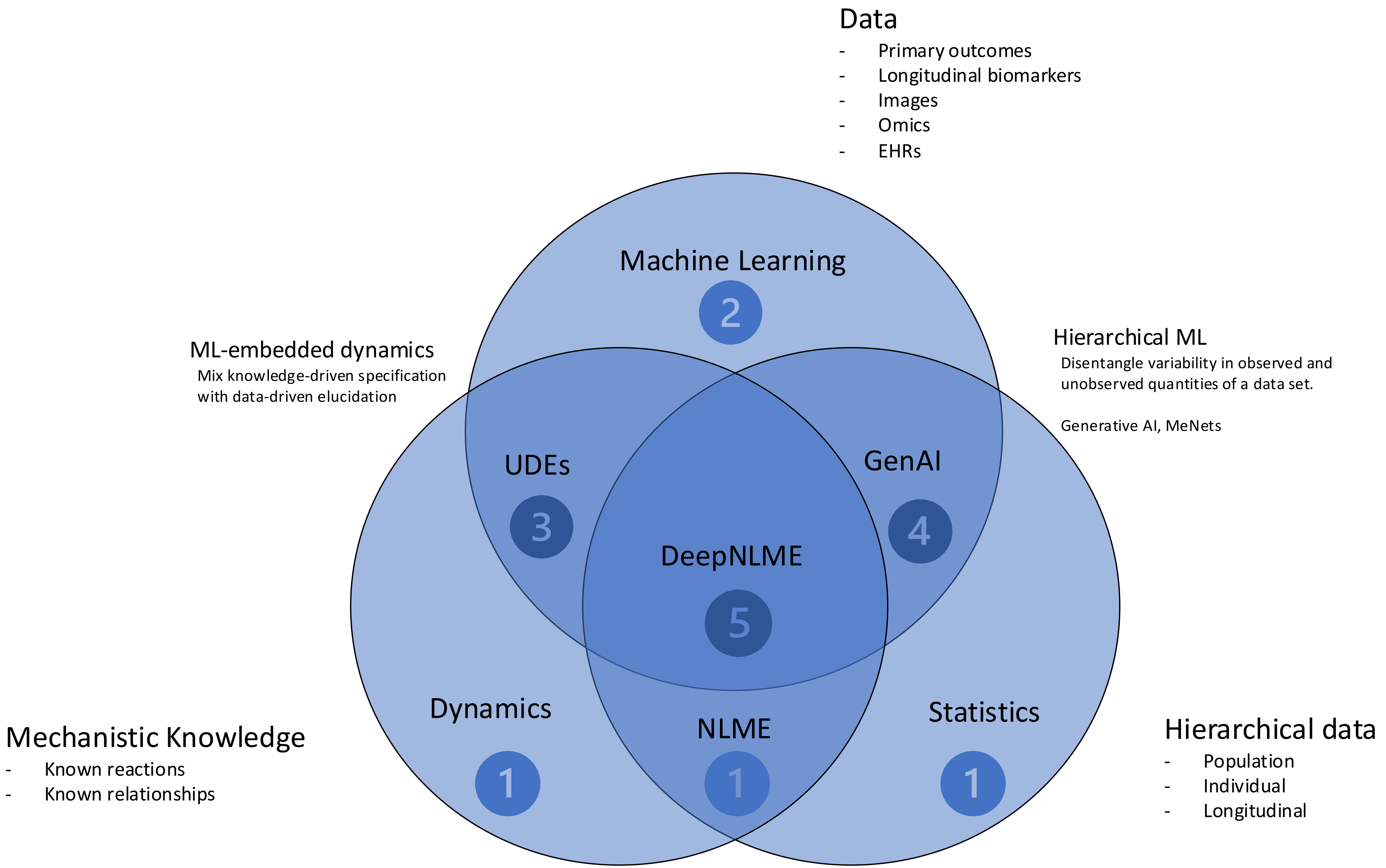
DiffEQ terms

Image  Parameter contribution

Time after first dose
Random effects  Individualizable longitudinal biomarkers

Receptor drug occupancy
Random effect  Pain score

Dynamic variables
Random effects  Individualizable dynamics term


Data
- Primary outcomes
- Longitudinal biomarkers
- Images
- Omics
- EHRs
Machine Learning
2
ML-embedded dynamics
Mix knowledge-driven specification with data-driven elucidation
Hierarchical ML
Disentangle variability in observed and unobserved quantities of a data set.
Generative AI, MeNets
UDEs
3
GenAI
4
DeepNLME
5
Dynamics
1
NLME
1
Statistics
1
Mechanistic Knowledge
- Known reactions
- Known relationships
Hierarchical data
- Population
- Individual
- Longitudinal