

# Mathematics for Clinical Decision Support

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Institut für Mathematische Optimierung  
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# Clinical Decision Support

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Wikipedia says:

A clinical decision support system (CDSS) is a health information technology, provides clinicians, staff, patients, or other individuals with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care.

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“CDSS **link health observations with health knowledge** to influence health choices by clinicians for improved health care”.

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“CDSS [link health observations with health knowledge](#) to influence health choices by clinicians for improved health care”.

Examples from this lecture

- How can we use measurements of absolute numbers of blood cells to predict/influence future behavior?
- Can an algorithm classify cardiac arrhythmias from ECGs?
- How should heart assist devices be controlled?
- When and how much insulin should be given to a patient?

# Mathematics

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“... link health observations with health knowledge ...”

How?

“... link health observations with health knowledge ...”

How?  $\Rightarrow$  **Mathematical Models**

- Use a prediction function space  $\mathcal{H}$ , like
  - Differential equation models, e.g.,

$$\dot{x}(t) = f(x(t), u(t), p), \quad r(x(0), p) = 0$$

- Neural Networks or Support Vector Machines
- ...
- Hybrid models

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- Fit the model to labeled training data  $(x_i, y_i)_{i \in [n]}$  with  $x_i \in \mathcal{X}$ ,  $y_i \in \mathcal{Y}$

$$\min_{h \in \mathcal{H}} \underbrace{\frac{1}{n} \sum_{i=1}^n \ell(h(x_i), y_i)}_{\text{empirical risk, data fit}} + \underbrace{\Omega(h)}_{\text{regularization}}$$

# Preliminary Table of Contents

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- 1 Modeling
- 2 CDS Case Studies (most from oncology and cardiology)
- 3 Simulation
- 4 Sensitivity Analysis
- 5 Parameter and State Estimation
- 6 Identifiability
- 7 Optimization
- 8 Optimal Control
- 9 Experimental Design
- 10 Dual Control
- 11 Machine Learning

All concepts shall be explained and applied to the CDS case studies.



# Optimierung in Magdeburg

## Vorlesungszyklus Sebastian Sager:

	Wann	Titel	SWS	Zielgruppe
S0	WS	Einführung in die Optimierung	4+2	B3
S1	WS	Nichtlineare Optimierung	4+2	B5, M1
S2	SS	G.-g. nichtlineare Optimierung	3+1	B4,B6,M2
S3	WS	Optimization for Machine Learning	4+2	M1
S4	SS	Algorithmic Dynamic Optimization	3+1	M2

## Vorlesungszyklus Volker Kaibel:

	Wann	Titel	SWS	Zielgruppe
K0	WS	Einführung in die Optimierung	4+2	B3
K1	WS	Kombinatorische Optimierung	4+2	B5, M1
K2	SS	Ganzzahlige Optimierung	3+1	B4,B6,M2
K3	WS	<del>Geometrische Methoden der DO</del>	4+2	M1
	WS	Mathematics for Clinical DS	4+2	M1
K4	SS	Algebraische Methoden der DO	3+1	M2

# Organisational Stuff

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## Ideally

- Knowledge of basic lectures Bachelor in Mathematics
- Programming skills
- Interest in medical applications

## Suited for

- Master students Mathematics
- Master students Statistics after consultation
- PhD students

## Continuation possible

- can be combined with any 3+1 master lecture
- Hiwi jobs
- Master thesis
- PhD thesis