Tamed Cancer

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Contents

- Healthcare 4.0 (Personalized healthcare)
- Tamed cancer problem statement
- Research concept
- Methodology & impact
Industrie 4.0: The next Industrial Revolution

- Industrie 1.0
  - End of 18th century
  - First mechanical loom (1784)

- Industrie 2.0
  - Start of 20th century
  - First production line, Cincinnati slaughterhouses (1870)

- Industrie 3.0
  - Start of 1970s
  - First programmable logic controller (PLC), Modicon 084 (1969)

- Industrie 4.0
  - Since 2010
  - Cyber-physical Systems (CPS)
Evolution of Medical Knowledge

"SCIENTIFICATION"

**Clinical**
- Descriptive
- Empiric

**Research**

**Basic**
- Investigative
- Scientific

**Verification by Experimentation**

1.0
- Early Antiquity
- Greece Rome
- Renaissance
- Anatomy

2.0
- Scientific Revolution
- Pathology
- Physiology
- Chemistry
- Bacteriology

3.0
- 19th Century
- Pharmacology

4.0
- 20th Century

**Healthcare 4.0**
- Tamed cancer problem statement
- Research concept
- Methodology & impact
Intentional healthcare behavioral

mHealth
healthcare mobile apps, devices & solutions

PRESENT

Smartphones are most popular among doctors after the stethoscope
62% of physicians are now using tablets, with over half of them using it at the point-of-care.

71% of nurses are using smartphones at work

247mn people have downloaded a health app

40,000 medical apps now available for Tablets and Smartphones

59% of patients in emerging market use at least one mHealth application or service, compared with 35% in the developed world

TOP 5 HEALTH CARE TRENDS OF 2016

1. Higher drug prices
2. Increase of smartphone nr.
3. Behavioral healthcare increase
4. Community-based care
5. Intentional consumer expenses
Personalized healthcare (model-based physiological control)

Medical knowledge
- Cancer treatments
- General protocols

Healing of the patient
- Find more effective solutions in healing
- Individual treatment for the patient

Model identification
- Model-based protocols

Engineering knowledge
- Healthcare 4.0
  - Tamed cancer problem statement
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Biomedical Engineering

PROJECTED PERCENTAGE INCREASES IN STEM JOBS: 2010–2020

STEM = academic disciplines in Science, Technology, Engineering, and Mathematics
Research trends

Personalized Medicine
Smart Cyber-Medical Systems

Personalized healthcare
Big-data
Cloud computations
m-Health
e-Health

Medical imaging
Safety critical systems

Evidence-based medicine
Physiological modeling and control
Automatic drug-delivery
Diabetes:
Artificial pancreas

Cancer:
Antiangiogenic TMT

Biostatistics:
Evidence based medicine

Hemodialysis:
Peristaltic pump control
Cancer statistics

- **EU 2016**: ≈ 1.3 million tumor-related deaths\(^1\)

- **Hungary\(^2,3\)**:
  - Leading in the EU!!
  - Listed 3rd in the World:
    - Listed 1st among men: 235.5/100000.

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1 – M. Malvezzi et al. *Ann Oncol*, **00**: 1-7
3 – http://chartsbin.com/view/lhq.4
Mission

Optimal { drug-delivery efficiency } control algorithm

Model-based personalized treatment
Less harmful cancer therapy
Increased life expectancy

Tamed cancer
Cancer treatments

Surgical oncology
- The tumor cells can be totally removed (zero-order kinetics)
- Tumor can be recurrent in many cases

Chemotherapy
- Uses drugs to destroy cancer cells
- Acts in general ways (by killing rapidly dividing cells)
- Have many side effects
- Tumor cells can become resistant to chemotherapy drugs

Radiotherapy
- Destroy cancer cells with radiation
- Acts in general ways (by killing rapidly dividing cells)
- Have many side effects

Targeted molecular therapies (TMTs)
- Fight specifically against different cancer mechanisms
- Can be more effective and have limited side effects
Antiangiogenic therapy

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**Tumor is dormant**
- Somatic mutation
- Small avascular tumor

**Angiogenic switch**
- Tumor secretion of angiogenic factors stimulates angiogenesis
- Rapid tumor growth and metastasis

Concept of the research

Individualization level

- **Controller-based individualized treatment**
- Conventional cancer therapies (chemotherapy, radiotherapy)

Quality of life (QoL)

- Virtually no side effect
- Infrequent and limited side effects
- Frequent and serious side effects

Cost of the treatment

- Low
- Medium
- High
Tumor volume control – output simulation results

Current (Hungarian) medical protocol

No treatment

Control approach
- Robust control
- Nonlinear control (LPV)
- Empiricism & Rationalism

Goal

Novel modern robust control algorithm to stop angiogenesis process of the tumor.

optimize drug intake (cost) & therapy efficiency (quality)

Objectives

O1 Novel tumor growth model identification

O2 Quasi-continuous low-dosage therapy protocol

O3 Optimal robust control algorithms for continuous low-dosage therapy


Healthcare 4.0

Tamed cancer problem statement
Research concept
Methodology & impact
- **Boosting** interdisciplinary cancer research competence
- **Personalized & optimal drug-delivery** approach
Animal experiments (constant quasi-continuous low-dosage)

Determine most effective therapy

Novel treatment protocol

Therapy validation

Therapy validation by further animal experiments

LPV-based robust control (Harvard-model)

Model identification

Novel tumor growth model

Continuous time controllers

Variable quasi-continuous low-dosage administration

In silico simulations

Model validation

Evidence-based personalized cancer therapy

1st year

2nd year

3rd–5th year

ENGINEERING SIDE

MEDICAL SIDE
Scientific impact

- Novel tumor growth model  
  novel in cancer science

- Quasi-continuous low dosage antiangiogenic protocol  
  novel in medical practice

- LPV-based nonlinear robust control algorithm  
  breakthrough in cancer therapy

Personalized model-based antiangiogenic therapy

Social impact
ERC Starting Grant 2015 Call
Grantees by Country of Host Institution & domain
Total 291 grants

23 countries

Number of grantees

Social Sciences and Humanities
Physical Sciences and Engineering
Life Sciences

UK: 48
DE: 47
NL: 32
FR: 29
IT: 24
CH: 21
ES: 18
BE: 12
SE: 10
AT: 10
IE: 9
DK: 6
CZ: 5
FI: 4
GR: 3
HU: 3
FR: 2
TR: 2
EL: 2
MT: 1
NO: 1
RO: 1

Healthcare 4.0
Tamed cancer problem statement
Research concept
Methodology & impact
ERC Tamed Cancer team members

**Dr. Tamás Ferenci**
- senior lecturer
- Σ publications = 140
- H-index = 5
- 2016 publications = 26

**Dr. Johanna Sájevicsné Sápi**
- senior lecturer
- Σ publications = 31
- H-index = 7
- 2016 publications = 3

**György Eigner**
- PhD student
- Σ publications = 31
- H-index = 1
- 2016 publications = 10

**Dr. Dániel András Drexler**
- senior lecturer
- Σ publications = 47
- H-index = 6
- 2016 publications = 5

**Dr. Dávid Csercsik (PPKE)**
- Post-Doc
- Σ publications = 44
- H-index = 4
- 2016 publications = 4

**Krisztina Geresdi**
- research assistant
PhysCon Research Center members

József Klespitz
- PhD student
- Σ publications = 13
- H-index = 2
- 2016 publications = 5

Obuda University
- 4 MSc students
- 2 BSc students

BME
- 5 MSc students

Péter Pázmány Chatolic University
- 2 MSc students

Ghent University
- 1 MSc student

National University of Singapore
- 2 MSc students

Róbert Pethes
- PhD hallgató
- Σ publications = 5
- H-index = 1
- 2016 publications = 4

Péter Szalay (Bosch)
- PhD student
- Σ publications = 26
- H-index = 4
- 2016 publications = 1
Thank you for your attention!

**Contact:**

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Óbuda University,  
Research and Innovation Center of Óbuda University,  
Physiological Controls Research Center
• 14:05 – Dr. Johanna Sápi  ➔  Engineering methods for cancer treatment

• 14:25 – Dr. Dávid Csercsik  ➔  Control-oriented modelling of tumor and tumor vasculature growth

• 14:45 – Dr. Dániel A. Drexler  ➔  Control engineering challenges and results