AI Planning in Medicine

Arturo Gonzalez-Ferrer
About me

• PhD in Computer Science, 2011
  – University of Granada
  – Development of Knowledge Engineering techniques for AI HTN Planning & Scheduling (e-learning, healthcare and business process management)

• Postdoc in University of Haifa, Israel
  – MobiGuide Project www.mobiguide-project.eu
    • Clinical Decision Support System for Physicians and Patients to manage the care process of Gestational Diabetes and Atrial Fibrillation “anytime and everywhere”
scheduling patient - hospital beds
conducting clinical trials protocols
Intensive Care Units

This picture is attributed to the author and it is licensed under CC BY-NC 2.0 (source at http://www.flickr.com/photos/martinlabar/2230004679/)
Risk and consequences assessment
Treatment Planning

This picture is attributed to the author and is licensed under CC 2.0 (SOURCE http://www.flickr.com/photos/littlesister/492937184/)
People may think:

**AI applied to Medicine?!**

I don’t trust computers that much
Some impressive numbers...

• A 2000 *Institute of Medicine* report estimated that medical errors are estimated to result in about between **44,000 and 98,000** deaths and **1,000,000** excess injuries each year in U.S. hospitals.

• A 2006 follow-up study found that medication errors are among the most common medical mistakes, harming at least **1.5 million people every year**.  
  – According to the study, 400,000 preventable drug-related injuries occur each year in hospitals, 800,000 in long-term care settings.
Evidence-based Medicine and Clinical Guidelines

- Clinical Guidelines and Protocols are used for:
  - improving quality assurance
  - reducing variation in clinical practice
  - guiding data collection
  - better interpretation and management of the patient's status
  - improving decision support
  - activating alerts and reminders
Therapy Planning

Traditional AI Planning approaches are based on assumptions like deterministic behavior, which do not always hold in medical domains.

Requirements in Medicine are higher than in typical toy-problems!

Unpredictable nature of the domain

- Context-sensitive +
- Task-specific sub-processes:
  - plan generation,
  - plan verification,
  - plan visualization,
  - plan execution,
  - plan modification,
  - plan critiquing

- Challenges:
  - Knowledge Engineering
    - Acquisition
    - Verification and Validation
  - Temporal representation and management
  - Data Integration
  - Exception handling
    - mixed initiative planning needed in many cases
Temporal Monitoring

• States, events, actions, plans, goals, and effects are durative
  – This makes monitoring of the states and events during execution of durative actions necessary

• The states model of a plan engine may need to consider more than plan generation
  – E.g. Plan suspension, completion, abortion.

• The domain is not static, many unpredictable events can occur
  – Depends on the domain (low/high frequency domains)
Care Team Management

• Medicine is applied by a team of physicians, nurses, etc. (roles), and they use a number of resources (e.g. x-ray machines)

• The plans to be generated from clinical protocols may need to consider these institutional constraints and deliver a personalized plan for patients and physicians
Oncotheraper Project

• 7 hospitals in Spain, area of Pediatric Oncology

• Oncologists are required to apply Clinical Guidelines for treating sick patients
  – complex temporal constraints

• They want to have personalized care process for
  – patient
  – medical staff + institutional requirements

• They want to reduce the time spent on preparing treatments
What do we get?

A fragment of the generated care pathway:

Deployed into a BPM engine (ubiquitous execution)
References

• Fox J, Subrata D., Safe and Sound: Artificial Intelligence in Hazardous Applications. AAAI Press 2000


• Fdez-Olivares J et al., Supporting clinical processes and decisions by hierarchical planning and scheduling, *Computational Intelligence* 2011; 27 (1): 103-122

• Gonzalez-Ferrer et al., Automated generation of patient-tailored electronic care pathways by translating computer-interpretable guidelines into hierarchical task networks *Artificial Intelligence in Medicine*, Elsevier 2012

• Glasspool DW, Fox J, Oettinger, A Smith-Spark J, Argumentation in Decision Support for Medical Care Planning for Patients and Clinicians, *AAAI Spring Symposia* 2006
Credits:
Arturo Gonzalez-Ferrer
Postdoc at University of Haifa, Israel
MobiGuide Project: www.mobiguide-project.eu
E-mail: arturogf@decsai.ugr.es
Website: http://www.ugr.es/~arturogf/

Thanks to:
Juan Fdez-Olivares and Luis Castillo, leaders of the Oncotheraper project and founders of IACTIVE Intelligent Solutions (www.iactiveit.com)
John Fox, Silvia Miksch, Mor Peleg for their excellent contributions in AI in Medicine, in which part of these slides are inspired
Prof. Austin Tate for inviting me to prepare this material