THE MUSE PROJECT

Marie-Francine Moens Katholieke Universiteit Leuven, Belgium

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joint work with the whole MUSE team

MUSE project

- MUSE: **Machine Understanding for interactive StorytElling**
- Algorithms for translating text into virtual worlds, 9/2012-8/2015, EU FP7-296703 (FET-open call)

Teesside University

Institut “Jožef Stefan”

Universiteit Leiden

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Outline

3

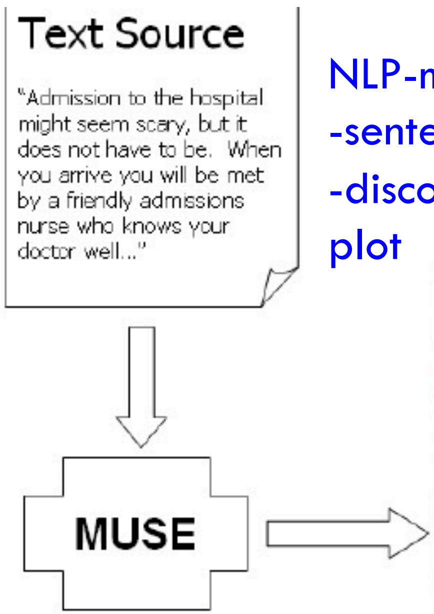
- Introducing **the MUSE project**
- Goals of the MUSE project
- Part 1: Machine understanding (Marie-Francine Moens)
  - Goals of the **natural language processing** in MUSE
  - **Challenges** (and solutions) of machine understanding of text
- Part 2: Interactive storytelling (Marc Cavazza)

Motivation for MUSE

- Bringing written text to "life" in a 3-D world with which the user can interact
- Result will be a novel form of communication of the information that is resided in written text

MUSE on one slide

Machine **U**nderstanding for
interactive **S**torytElling
MUSE



NLP-modules: semantic processing
-sentence level: event structure: who is doing what, where and when, …
-discourse level: event relations: mainly temporal and causal, narrative plot

Representation in planning language

Instantiation of virtual reality

Storytelling is evaluated with real users:
-children, students
-hospital patients

Overall goals of MUSE

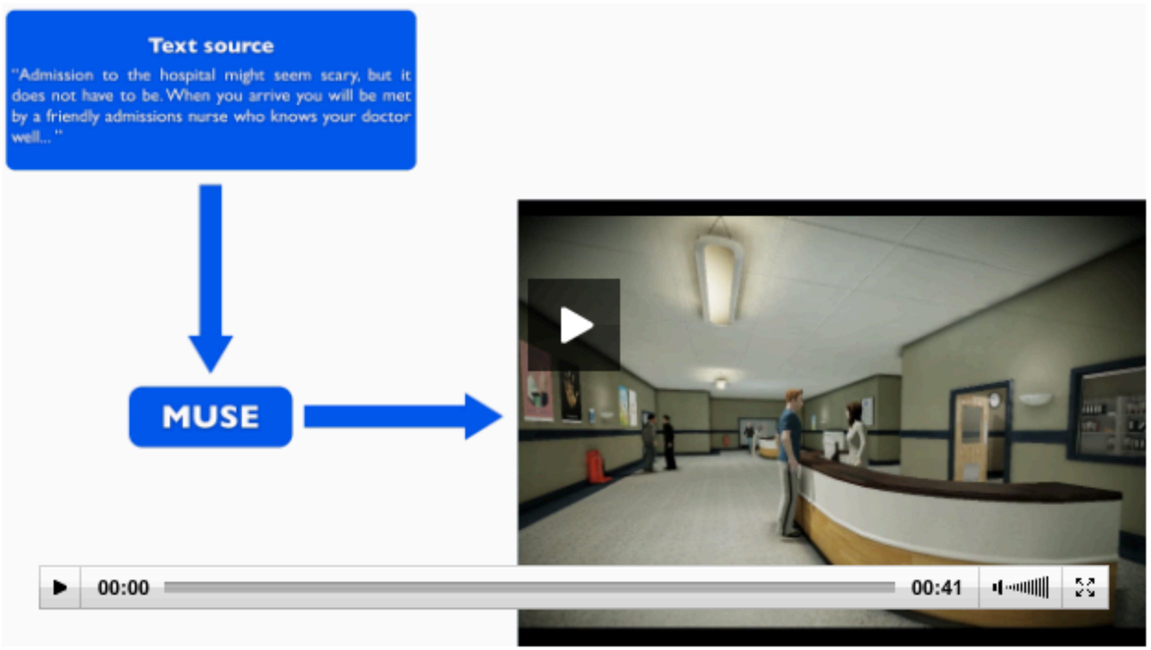
1. To develop the conceptual and theoretical framework
2. To design and implement the MUSE methodology
3. To implement the proposed MUSE methodology as a workflow of executable procedures in a prototype
4. To demonstrate the utility of the MUSE methodology framework and to evaluate and assess its properties on the basis of demonstration scenarios
5. To analyse the proposed MUSE methodology and its prototype
6. To widely disseminate the results of the project

Use cases of MUSE

Use cases: children's stories and patient education guidelines

render these as 3D-virtual worlds

http://www.muse-project.eu/



Overall goals of MUSE

- **Objective 2: To design and implement the MUSE methodology**
  - Novel natural language processing algorithms for information extraction
  - Novel planning, as well as scenario and script creation algorithms, resulting in an automatically created semantic narrative
  - 3D animation of the semantic narrative
  - Novel algorithms for end-user interaction with the animated semantic narrative
  - Novel evaluation procedures with end users

- Part 1: Machine understanding

Goals of natural language processing in MUSE

- **Can a machine understand natural language as we humans do?**
- Assumption:
  - If we can bring the content of the text to life in a 3D world and the understanding of this content by humans is at least as good compared to when reading the text, the machine has succeeded this test
- **What kind of natural language processing - which might not exist yet - is needed in an interactive storytelling environment?**

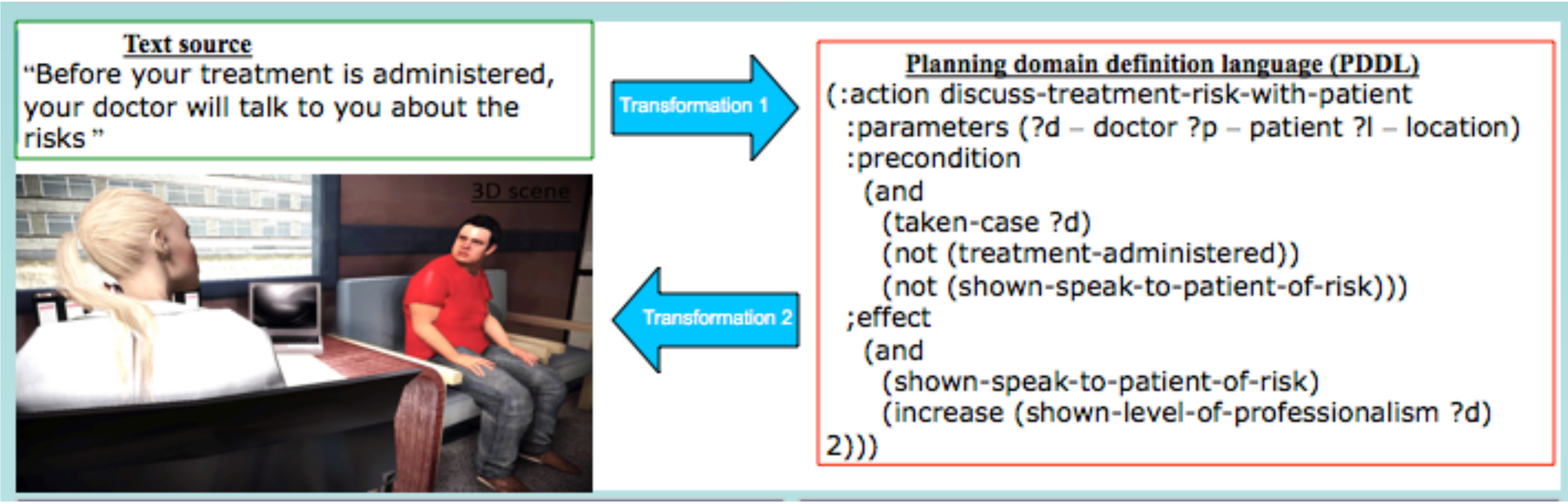
What can NLP already do?

- **NOT MUCH**
  - Part-of-speech tagging, recovering the syntactic structure of a sentence
  - Recognition of actions/events and their semantic roles (actor, patient, instrument, location, …)
  - Resolution of coreferent noun phrases
  - Recognition of temporal and spatial information, including temporal relations between events and spatial relations between objects
  - Scope of negation, modality

  …, **FRAGMENTARY RECOGNITIONS**, **BUT VALUABLE !**

… far from what is needed in MUSE

- **Mapping** needed to PDDL **knowledge representation**

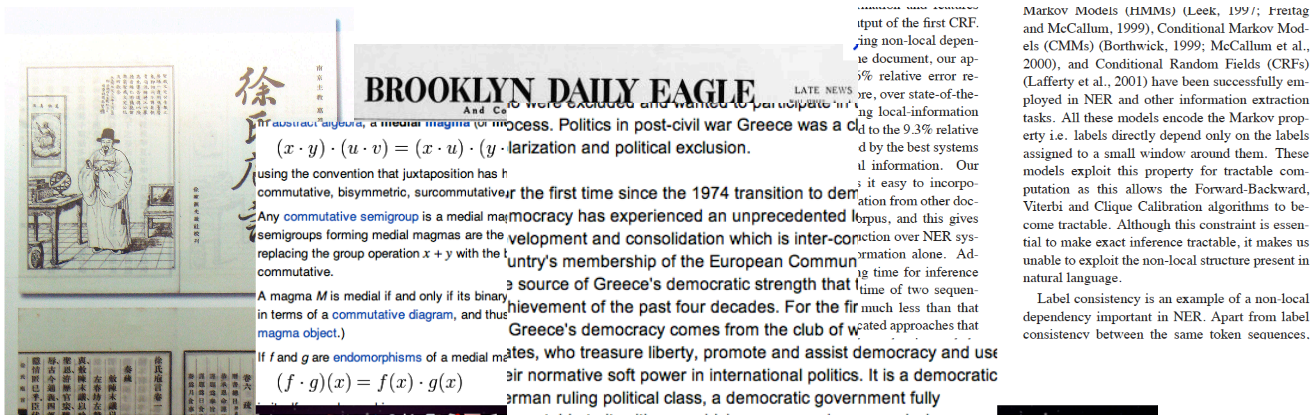


Challenges of the machine understanding

- Lack of training data: leveraging unlabeled data
- Mapping to meaning or knowledge representation
- Parsing of discourse structure
- Lack of domain/world knowledge
- …

Lack of training data

- Common approach: train a classifier for the semantic recognitions on set of annotated examples
- Lexical items (words) are very important: they carry an important part of the semantic meaning
- Many, many different words in a language ! Many of which are never seen in the training examples !
- To make it worse: we do not have annotated training data for the children stories and patient guidelines



Leveraging unlabeled data

- In MUSE we train language models on a large collection of unlabeled data:
  - Latent words language model (probabilistic graphical model)
  - Language model based on recurrent neural network
- Creation of extra training examples based plausible substitutions given by the language model and linguistic constraints
- => Improved portability and thus performance on MUSE texts

[Do Thi Ngoc et al. will be submitted EACL]

Language model

Compuserve	**corp**	**said**	**Tuesday**	**it**	**anticipates**	**a**	**loss**
Microsoft	inc	told	Friday	they	expects	the	profit
Crysler	corp.	reported	Thursday	he	expected	some	gain
Oracle	ltd	added	Monday	she	assumes	an	deficit
Software	co	say	Wednesday	this	doubts	another	earnings

A	**Japanese**	**electronics**	**executive**	**was**	**kidnapped**	**in**	**Mexico**
the	U.S.	tobacco	director	is	abducted	on	Usa
its	German	sales	manager	we	killed	at	UK
an	British	consulting	economist	are	found	of	Australia
one	Russian	electric	spokesman	be	abduction	into	Canada

E.g., learning of synonyms and related words from a representative corpus [Deschacht & Moens EMNLP 2009] [Collobert et al. JMLR 2011] [Kolomiyets et al. ACL 2011] [Deschacht et aL CSL 2012] [Yates et al. Comp. Ling. 2013] [De Mulder et al. submitted CSP]

Mapping to KR

- Narrative stories: **parametrized action representation** integrated in narrative discourse structure
- Atomic actions, complex actions, connected events
  - Protagonists
  - Temporal and causal relations/preconditions – postconditions
  - …

[Badler et al. in Embodied conversational agents MIT Press 2001] [Mani Morgan&Claypool 2013]

- Marie was happy to oblige. She shouted upstairs to her brothers.

protagonist

atomic action

- blood test

complex concept: involves a series of actions

Then she returned to help her mom with Thanksgiving dinner. Mom and Marie had made the pies. The pies were in the pantry ...

different time lines ...

Mapping to KR

- Mapping to predicate-argument structure in first-order logic or other logic => **semantic parsing**
- State-of-the-art:
  - Rule based systems and supervised learning: not realistic to handcraft rules or consistently annotate complex concepts in the examples e.g., [Mooney CICLING 2007]
  - Learning based on paired sentences and their KR: needs corpus of paired examples, e.g., [Chen & Mooney ICML 2008] [Kim & Mooney COLING 2010] [Jones et al. ACL 2012] : MUSE does not have such corpus !

Mapping to KR

- Promising: **grounded unsupervised semantic parsing,** cf. learning of a probabilistic semantic grammar where non-terminal symbols are predicates and arguments defined for the application [Poon ACL 2013]
- But, unsupervised parsing is difficult, the computation of the latent variables needs many training data
- To compensate **in MUSE** !!!
  - The use of multiple evidences from the linguistic annotation
  - Consistency feedback with setting specific knowledge

when maximizing the likelihood of the grammar over the (limited) training data

=> **explains why the linguistic annotations are valuable**

Parsing discourse structure

- Patient (and other) guidelines exhibit a conditional structure to be recovered

These appointments have 6 main objectives:

- assess your weight loss;
- check that you are in good health, identify and treat any surgical complications and nutritional deficiencies that may occur soon after the operation or at a later stage;
- if necessary, adapt the medications you are taking: some medications may be less well assimilated or not assimilated at all after a malabsorptive operation while others may no longer be necessary in the longer or short term because of the weight loss achieved;
- check that you have successfully adapted to your new eating habits and physical exercise regime, and help you solve any day-to-day problems;
- detect any psychological problems related to the change in your body and, if necessary, offer appropriate care;

  Weight loss changes the body and its appearance: this can lead to psychological distress that may or may not be easy to deal with. A period of adaptation to the change is necessary and normal for yourself and your family. If you wish, or if your doctor feels it is necessary, you may be offered support from a psychologist or psychiatrist.
- if necessary, offer reconstructive surgery to remove excess skin that may remain in certain places after weight loss (breasts, stomach, arms and thighs);

Parsing discourse structure

- Recovering the correct dependency tree of the conditions and conclusions including correct logical interpretation of conjunctions, disjunctions and negations is a difficult problem
- => acquisition of a discourse parse grammar

Parsing discourse structure


```
T
|--D
|  |--: For these reasons, the Commission by a majority declares the application admissible,
|       without prejudging the merits.
|--A
   |--A
   |  |--C
   |  |  |--: It follows that the application cannot be dismissed as manifestly ill-founded.
   |  |--A
   |     |--P
   |     |  |--: It considers that the applicant 's  complaints raise serious issues of fact
   |     |       and law under the convention, the determination of which should depend on
   |     |       an examination of the merits.
   |     |--P
   |        |--: The Commission has taken cognizance of the submissions of the parties.
   |--A
      |--C
      |  |--: In these circumstances, the Commission finds that the application cannot be
      |       declared inadmissible for non-exhaustion of domestic remedies.
      |--A
         |--P
         |  |--: The Commission recalls that article art. x of the convention only requires
         |       the exhaustion of such remedies which relate to the breaches of the
         |       convention alleged and at the same time can provide effective and sufficient
         |       redress.
         |--P
         |  |--: The Commission notes that in the context of the section powers the
         |       secretary of state has a very wide discretion.
         |--P
         |  |--: The Commission recalls that in the case of temple v. the united kingdom
         |       no. x dec. d.r. p.
         |--P
            |--: The Commission held that recourse to a purely discretionary power on
            |    the part of the secretary of state did not constitute an effective
            |    domestic remedy.
            |--: The Commission finds that the suggested application for discretionary
                 relief in the instant case cannot do so either.
```

Fig. 6: Output of the automatic system: small fragment of the argumentation tree-structure of a document

Cf. our past work on recovering the argumentation structure of court decisions

[Mochales & Moens, AI & Law 2011]

Lack of domain/world knowledge

- Is present in MUSE in many flavors
- A few examples:
  - Lexical knowledge: an anesthesiologist is a physician
  - … everyone to the dining room. …Marie's father and uncle poked their heads in from the living room. … The kids and Marie's grandparents found their seats. Marie's dad, mom, uncle, and aunt were soon seated, and finally her brother Chris pulled up his chair and sat down.

Knowing that a dining room has chairs, knowing that a living room is a different location than the dining room, so needs change of location of the actors involved ….

Cf. [Engels et al. BMCV 2010]

Lack of domain/world knowledge

- Action mentions are incomplete

Mom asked Marie to help her. When Marie and her mother reached the pantry, ...

The actors mom and Marie are still sitting in the dining room (no indication in the text it has changed), then they reach the pantry, so they must have get up and walk (respective preconditions of walk and reach)

- A complex event such as a blood test is composed of several atomic actions:
  - Patient sitting in chair, patient raising arm, nurse cleaning arm, nurse pricking with needle, nurse taking blood, ...

Lack of domain/world knowledge

- Domain/world knowledge in MUSE:
  - Some very basic knowledge (e.g. physics) will always be manually encoded in the VR environment anyway
  - Automatically acquiring the world knowledge can reduce the need for hand-coding (but in MUSE we can still fall back on hand-coding world knowledge when necessary)
    - From the text itself (e.g., locations in examples above)
    - From other texts
    - From other sources and media
- Knowing when this background knowledge is relevant

row	s_1	s_2	s_3	s_4
1	∅	walk into restaurant	∅	enter restaurant
2	∅	∅	walk to the counter	go to counter
3	∅	find the end of the line	∅	∅
4	∅	stand in line	∅	∅
5	look at menu	look at menu board	∅	∅
6	decide what you want	decide on food and drink	∅	make selection
7	order at counter	tell cashier your order	place an order	place order
8	∅	listen to cashier repeat order	∅	∅
9	pay at counter	∅	pay the bill	pay for food
10	∅	listen for total price	∅	∅
11	∅	swipe credit card in scanner	∅	∅
12	∅	put up credit card	∅	∅
13	∅	take receipt	∅	∅
14	∅	look at order number	∅	∅
15	∅	take your cup	∅	∅
16	∅	stand off to the side	∅	∅
17	∅	wait for number to be called	wait for the ordered food	∅
18	receive food at counter	get your drink	get the food	pick up order
19	∅	∅	∅	pick up condiments
20	take food to table	∅	move to a table	go to table
21	eat food	∅	eat food	consume food
22	∅	∅	∅	clear tray
22	∅	∅	exit the place	∅

Figure 2: A MSA of four event sequence descriptions

[Chamber & Jurafsky ACL 2009] [Regneri et al. ACL 2010] [Brams et al. EACL 2012]

Conclusions

- Machine understanding
  - There is a gap between the results of current natural language processing tools and machine understanding of text
  - As shown, the challenges have already yielded and will yield research-wise very interesting solutions
- Interactive storytelling
  - In the next talk we see how interactive storytelling helps with some of the problems and improved the communication of the content to users, which is the final goal of MUSE

- Special thanks to Oleksandr Kolomiyets, Quynh Do and Oswaldo Ludwig

Interactive Narratives from Patient Education Documents

Marc Cavazza (with Fred Charles Cameron Smith, Julie Porteous, Teesside University;
and Gersende Georg, HAS)

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The Problem

- Limited health literacy is a problem for public health

  Safeer, Richard S., and Jann Keenan. Health literacy: the gap between physicians and patients. *Am. Fam. Physician 72, 3* (2005), 463-468.

- Capitalise on popular media (computer games) for patient education following the development of serious games

  Graafland, M., Schraagen, J. M., Schijven, M. P. Systematic review of serious games for medical education and surgical skills training. British Journal of Surgery 99, 10 (2012), 1322–1330.

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Objectives

- Create “serious games” for patient education
  - Using the actual documents’ contents to produce the game
- … so that users can “rehearse” real-world situations
  - Makes background knowledge available which is not in the text

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Challenges

- (Serious) Games production costs, although cheaper than AAA games, are prohibitive for most Health organisations

- Need for new technologies to facilitate development (reuse, parameterisation, procedural content generation)

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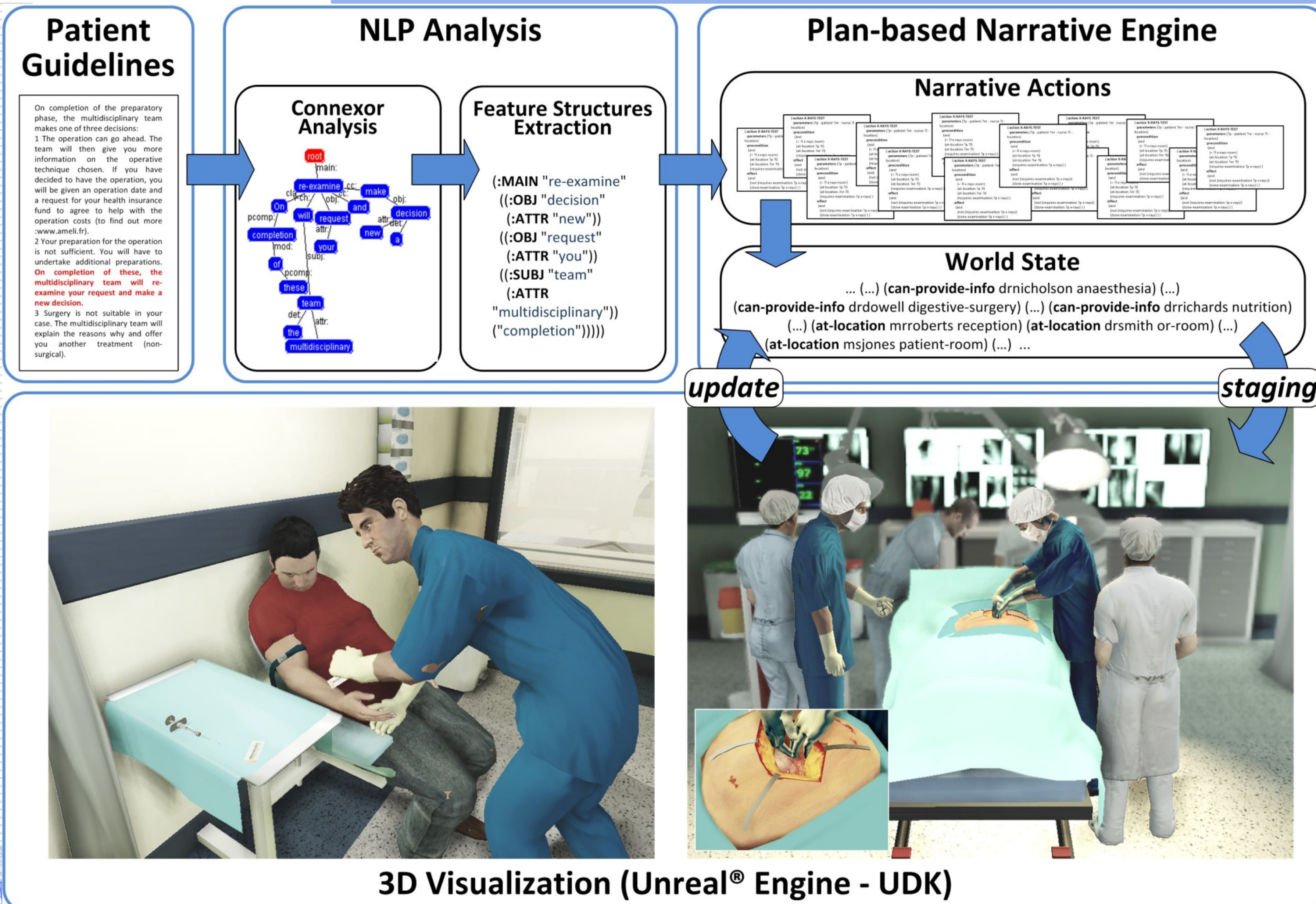
New technology: Interactive Narrative

- Dynamic Story generation supporting user intervention
- … a new application of Planning techniques

Text-Based Generation



Text-Based Generation of games …

- Is still *way* beyond the state-of-the-art
- Previous work mostly about generating animations from text (less emphasis on interaction or implicit knowledge) [Coyne and Sproat, 2001] [Badler et al., 1995]
- Our first step is the text-based parameterisation of pre-existing virtual worlds
  - which come with a set of characters, an ontology of medical procedures etc.

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Interactive Patient Education "Games"

- Allowing the user to freely explore the virtual world attempting various actions as she progresses through it. *The user should be allowed to take incorrect steps and see their consequences in a realistic way*
- It should not become a "platform game" in which the user can only progress through correct actions!

muse

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Scenario: Bariatric Surgery

- Bariatric surgery, or weight loss surgery is proposed as a treatment for severe obesity
- It requires important decisions to be made both by the patient and the medical team
- Patient information and education is of particular importance

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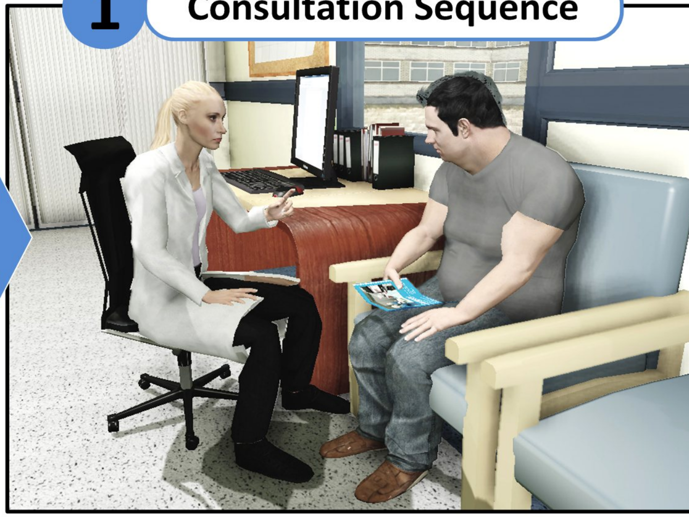
Scenario: Bariatric Surgery

Action Instantiation
(patient, specialist, location, topic)

Plan-based Narrative Engine

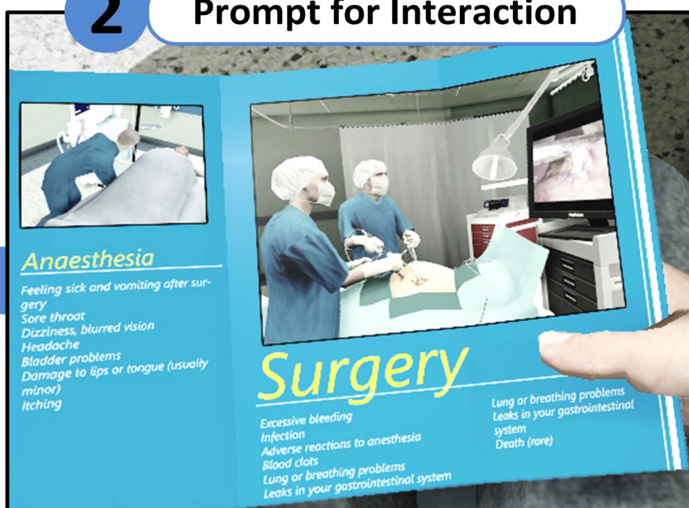
Modify Domain Knowledge
(**decided-surgery** ?p)

1 Consultation Sequence



(**:action CONSULTATION-WITH-SPECIALIST**
:parameters (?p - patient ?s – specialist ?t – topic
?l – location)
:precondition
(and
(hospital-office ?s ?l)
(at-location ?s ?l) (at-location ?p ?l)
(can-provide-info ?s ?t)
(...))
:effect
(and
(has-info ?p ?t) (...)))

2 Prompt for Interaction



(**:action PROMPT-INTERACTION-SURGERY-DECISION**
:parameters (?p - patient ?s – specialist
?l - location ?t - topic)
:precondition
(and
(hospital-office ?s ?l)
(at-location ?s ?l)
(at-location ?p ?l)
(has-info ?p ?t))
:effect
(and
(prompted-interaction-surgery-decision ?p)))

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Unreal Development Kit (64-bit, DX9)

Early NLP testing

- Instantiating pre-existing actions / domain knowledge
- Determining modes of Reference
- Discourse structure and their implications for the representation of explicit/implicit knowledge

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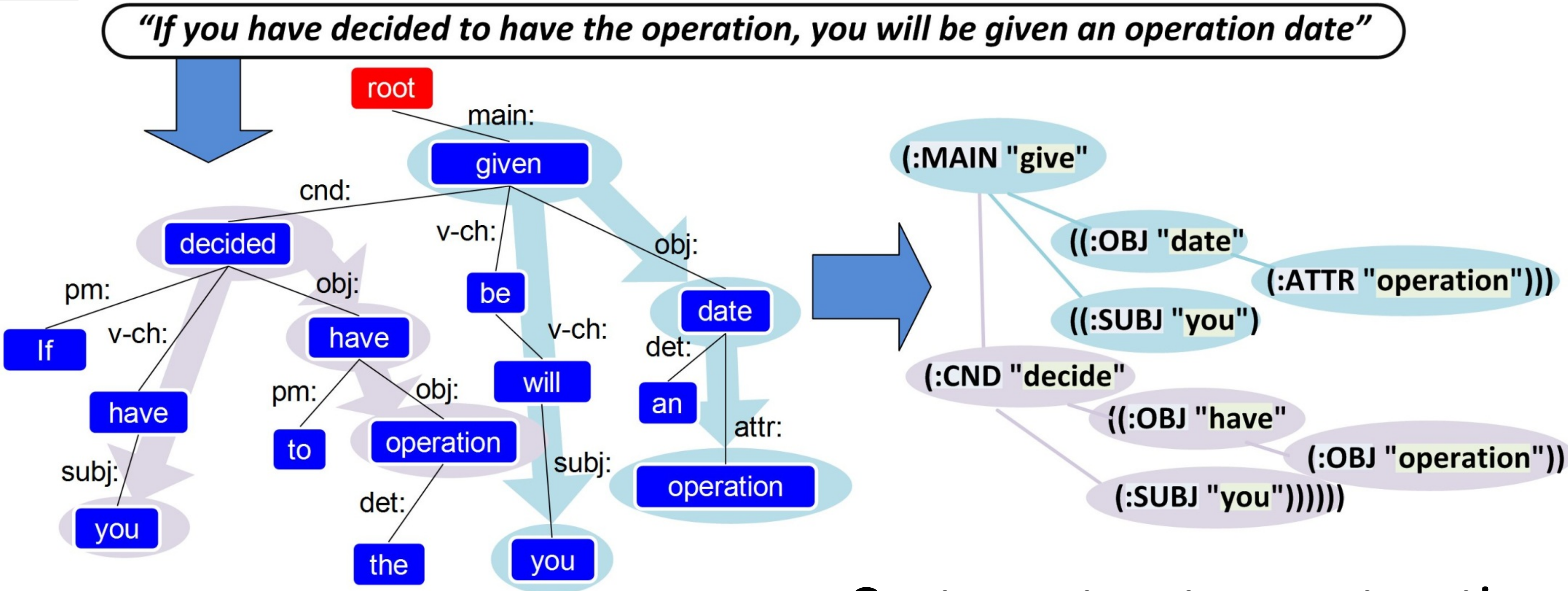
Feature Structures Extraction



Connexor® analysis

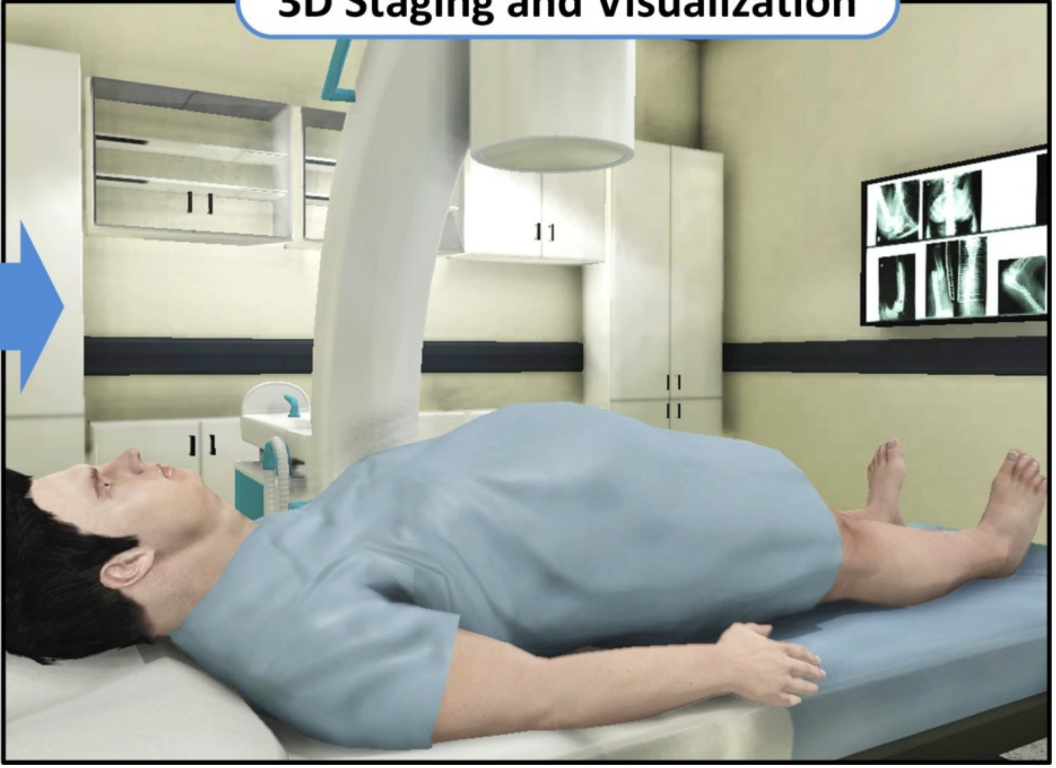
Custom structure extraction
Mapping onto the narrative representation

PDDL – AI Planning Representation

PDDL Operator

```
(:action X-RAYS-TEST
  :parameters (?p - patient ?nr – nurse
                ?l - location)
  :precondition
    (and
      (x-rays-room ?nr ?l)
      (at-location ?p ?l)
      (at-location ?nr ?l)
      (...) )
  :effect
    (and
      (...)
      (completed-examination ?p x-rays) ) )
```

3D Staging and Visualization



Animation Techniques

- Need to be interactive and dynamic (propagating consequences of actions)
- Plan-based behaviour (Planning keeps consistency of actions, individual actions, interaction)
- High-level action / low-level actions
- Even low level actions are parameterised but they relied on pre-existing data (characters, models, some animations)

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Patient examinations

They will also request various examinations (blood tests, upper gastrointestinal endoscopy* and, if necessary, X-rays, assessments of respiratory and cardiac function, pregnancy test and an examination of the mouth and teeth).

- Information extracted from patient document, although extra medical knowledge may be required:
  - Blood sample, Xray, …

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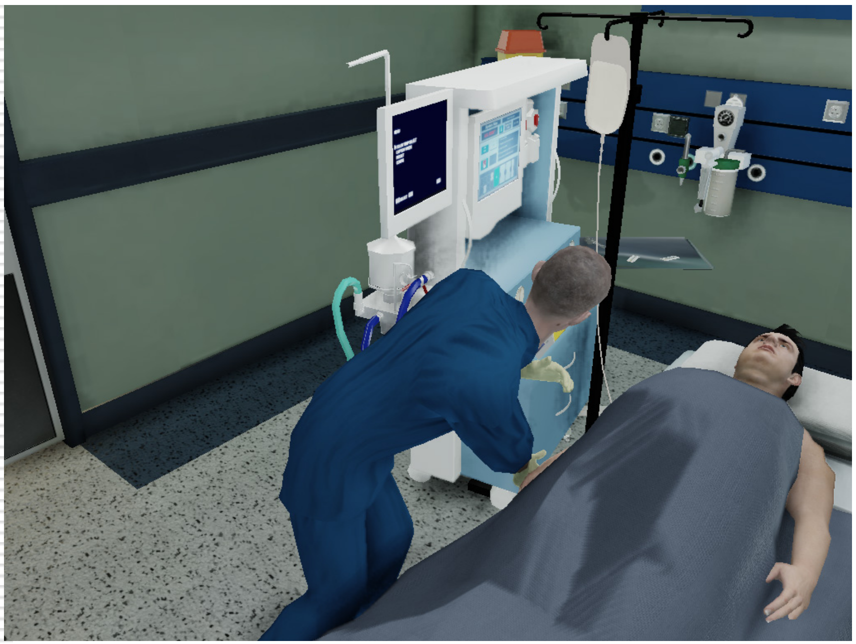
Example

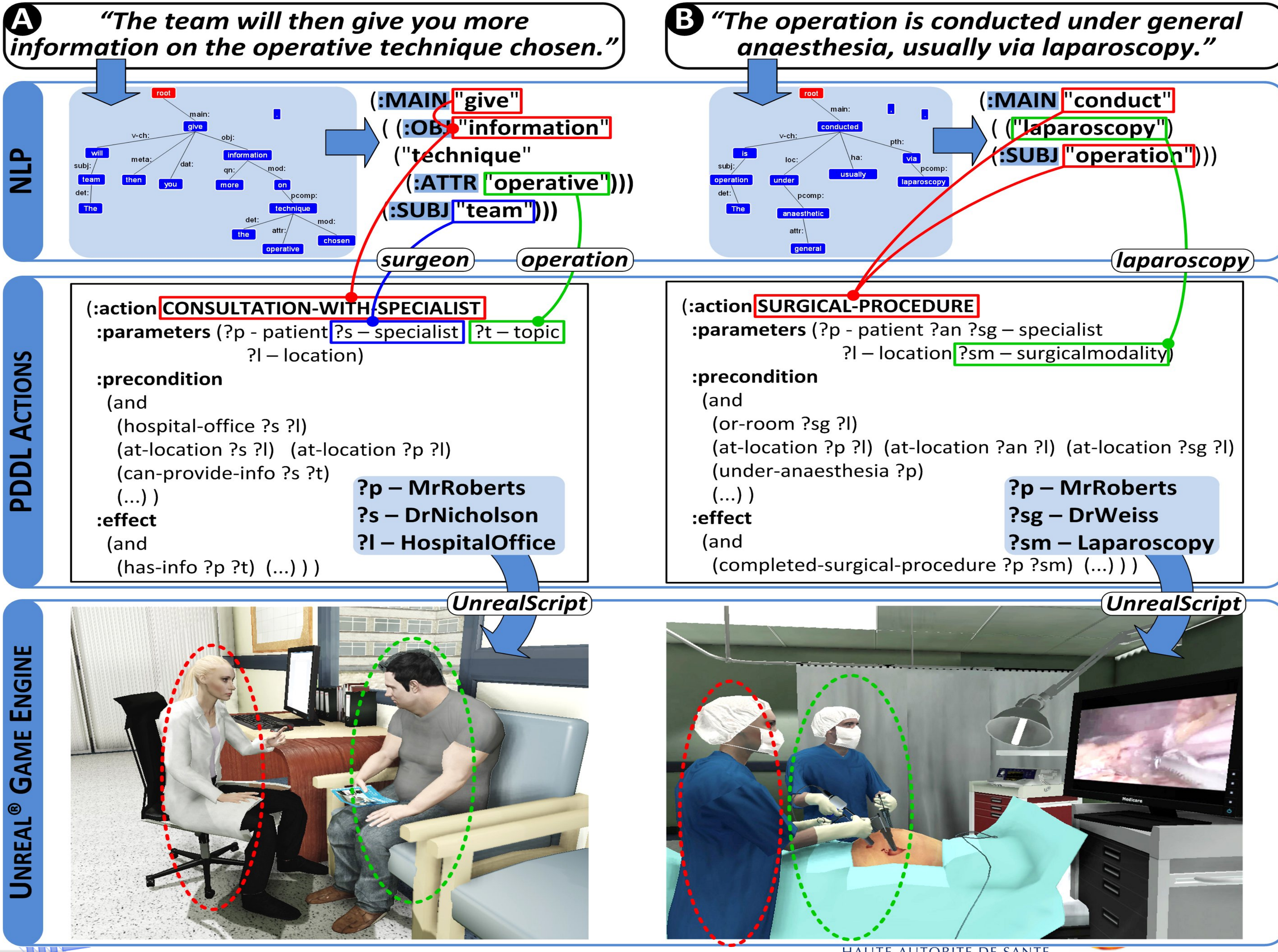
Dynamic change 1st 3rd person mode



Direct/indirect Reference to actions

- A recurring problem is when the patient documents is referring to actions about procedures (decision, discussion, information provision) or about procedures themselves

- Simple heuristics using surface structure and voice of the sentence mentioning the procedure


A
"The team will then give you more information on the operative technique chosen."
B
"The operation is conducted under general anaesthesia, usually via laparoscopy."
NLP
root
main:
give
v-ch:
obj:
will
meta:
dat:
information
subj:
team
then
you
qn:
mod:
more
on
det:
The
pcomp:
technique
det:
attr:
mod:
the
operative
chosen
(:MAIN "give"
((:OBJ "information"
("technique"
(:ATTR "operative")))
(:SUBJ "team")))
surgeon
operation
conducted
is
subj:
operation
loc:
under
ha:
usually
pth:
via
pcomp:
laparoscopy
det:
The
pcomp:
anaesthetic
attr:
general
(:MAIN "conduct"
(("laparoscopy")
(:SUBJ "operation")))
laparoscopy
PDDL ACTIONS
(:action CONSULTATION-WITH-SPECIALIST
:parameters (?p - patient ?s – specialist ?t – topic
?l – location)
:precondition
(and
(hospital-office ?s ?l)
(at-location ?s ?l) (at-location ?p ?l)
(can-provide-info ?s ?t)
(...))
:effect
(and
(has-info ?p ?t) (...)))
?p – MrRoberts
?s – DrNicholson
?l – HospitalOffice
(:action SURGICAL-PROCEDURE
:parameters (?p - patient ?an ?sg – specialist
?l – location ?sm – surgicalmodality)
:precondition
(and
(or-room ?sg ?l)
(at-location ?p ?l) (at-location ?an ?l) (at-location ?sg ?l)
(under-anaesthesia ?p)
(...))
:effect
(and
(completed-surgical-procedure ?p ?sm) (...)))
?p – MrRoberts
?sg – DrWeiss
?sm – Laparoscopy
UnrealScript
UnrealScript
UNREAL® GAME ENGINE
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Role of discourse structures

- Deontic structures can help to identify appropriate and inappropriate behavior / course of action
  - Note: deontic logic (Bailhache P,. *Essai de logique déontique*, Vrin, 1991) can be applied to the natural language expressions of clinical guidelines

- How can deontic knowledge be interpreted in the system?

How can deontic knowledge be represented in the system?

$$Op = F\neg p$$

- counterfactual reasoning: what is the status of $\neg p$?
  - In some cases, not undertaking the obligatory action
  - In others, undertaking an "opposite" / "incompatible" action

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Visualising non-compliance

	Show situation	Do not show
Obligatory action	✔	
Missing obligatory action	?	✔
Opposite action	✔	

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Representational issues

- It is thus required for actions taking part in deontic structures to represent their “contrary” actions

- Example

  “You should fast before a blood test”

Conclusions

- Knowledge should support Interaction!
  - Recognising factual knowledge and immersing it into background knowledge
  - Recognising discourse structures to interpret and stage recommended behaviour

Funded in part through EC FP7 Open FET project "MUSE" (FP7-296703)

Online publications at https://ive.scm.tees.ac.uk/

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