Impact of deception information on negotiation dialog management: A case study on doctor-patient conversations

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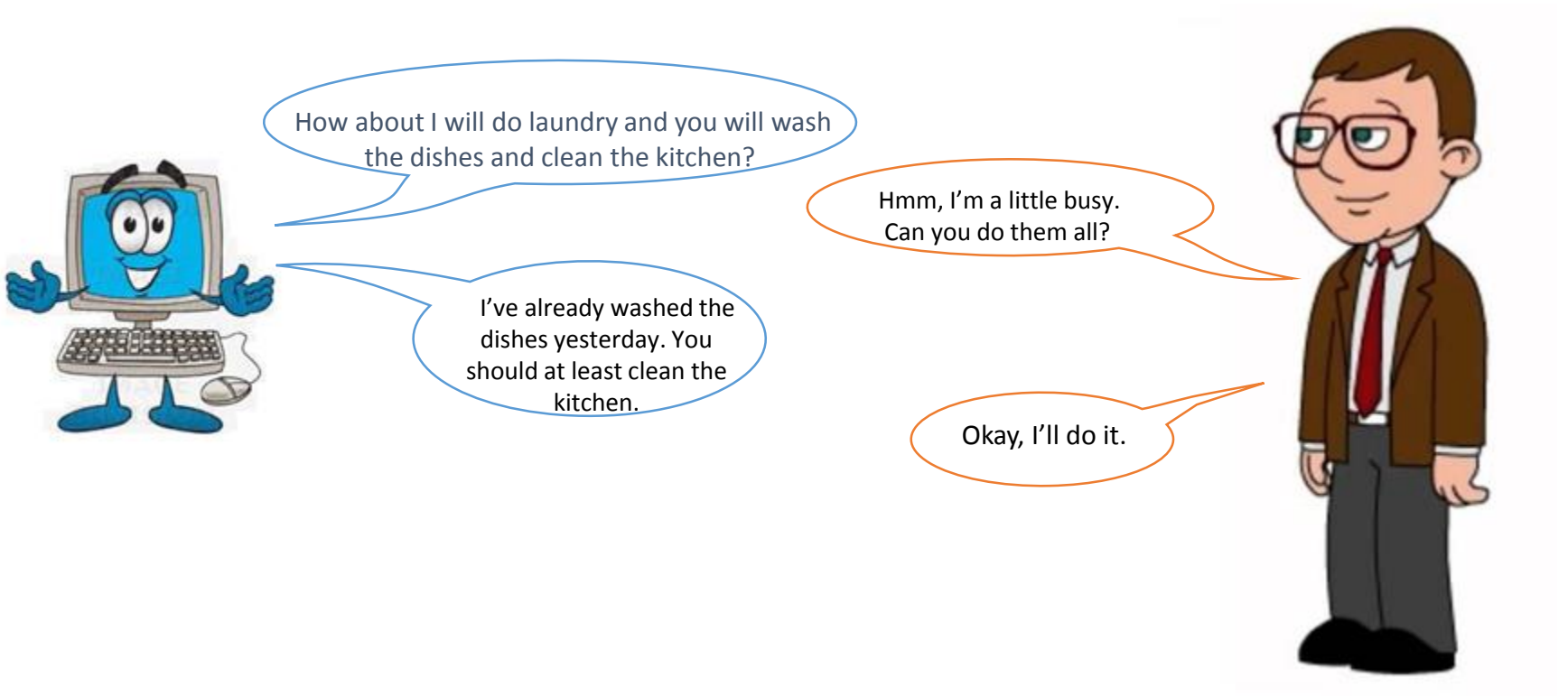
Negotiation and negotiation system



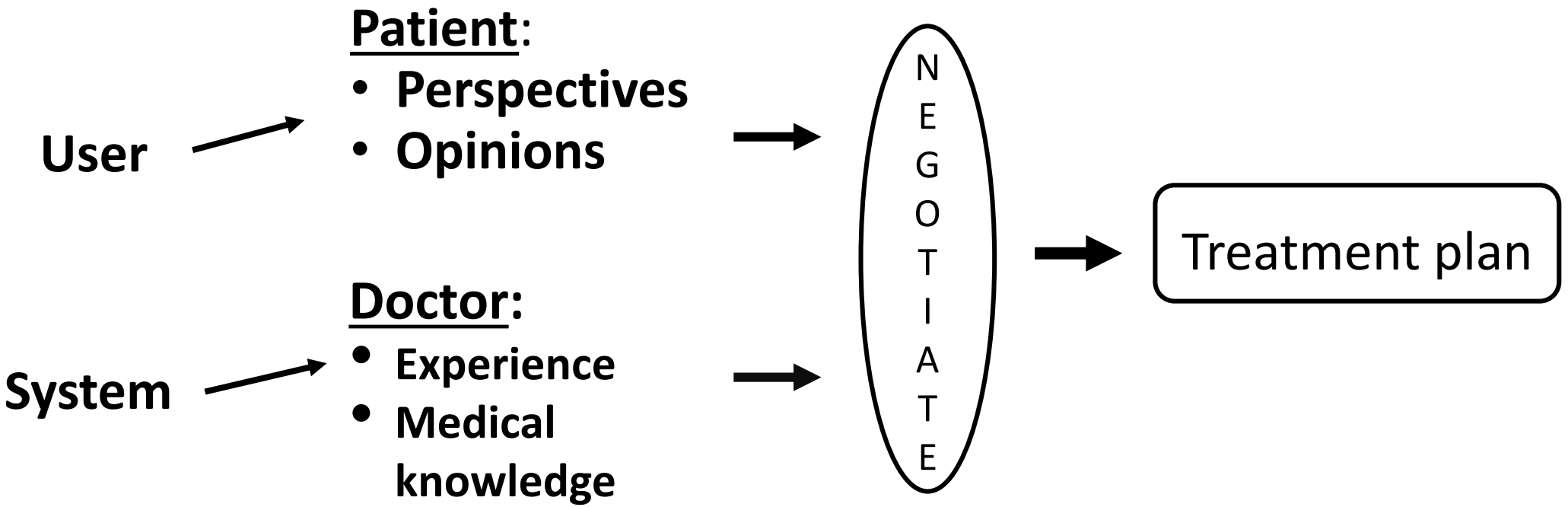
System (or agent) that **persuades** their interlocutor (a human user or another agent) to **agree on the system's preferences** by using the most appropriate types of **arguments** – Georgilla & Traum (2011)

Negotiation and deception

- Deception is a common strategy used in negotiation.
- Vourliotakis et.al 2014: an agent that can tell lies negotiates with a rule-based adversary in a trading game scenario.
- Chance of winning the game of the agent will be lowered if the adversary can tell when the agent is lying.

→ Deception information can be useful for the negotiation task.

Doctor – Patient conversation



Botelho (1992), Heaton(1981)

→ **dialog system can be used for Doctor-Patient conversation**

Problem with existing negotiation system

Existing negotiation systems **assume that the user only speak the truth**.

Surveys* showed that about **23-38% of patient tell lies to doctor**.

→ **<u>Proposal:</u> Dialog system knows when patient is lying and provides appropriate reaction.**

* Wall Street Journal (2009), Zocdoc (2015), WebMD (2004)…

Problems and Solutions

Problems	My solution
1. How can system detect user's lie?	1. Detect the lie using facial and acoustic clues.
2. How does system react to user's lie?	2. Design system behavior to react to user's lies.
3. How does system learn this behavior?	3. Modeled with POMDP and train by Q-learning

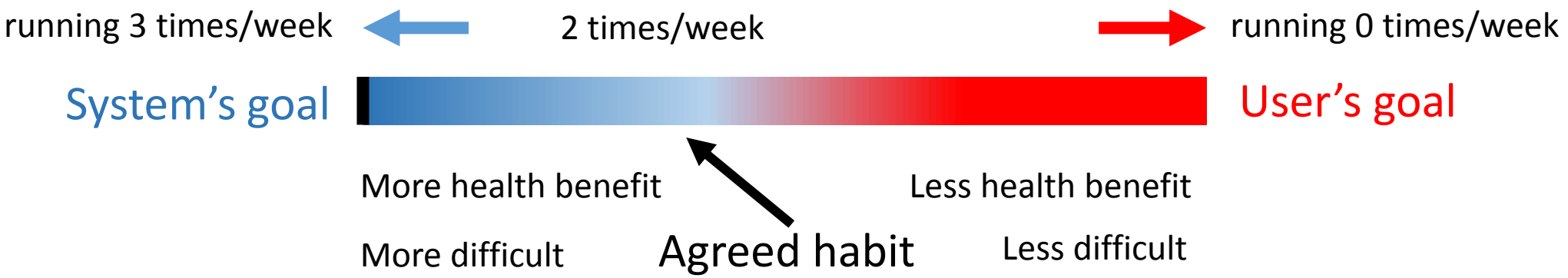
Dialog domain: changing living habits

General medical domain:
- **Many topics**
- **Require medical knowledge**

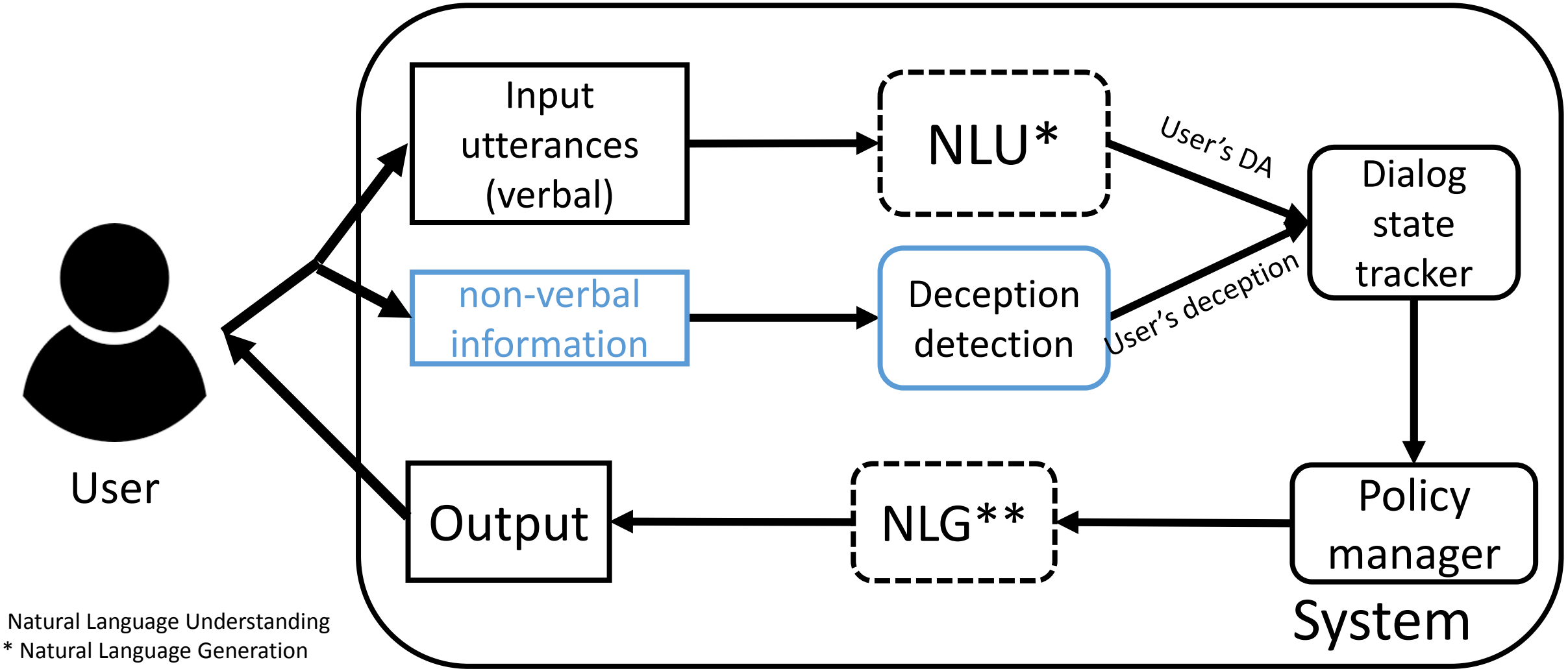
→ **Working domain**: user's living habits

- **Sleeping**
- **Eating**
- **Working**
- **Exercising**
- **Social media**
- **Leisure activities**

- **System's goal**: convince user to adopt a new living habit.
- **User's goal**: keep the current habit.



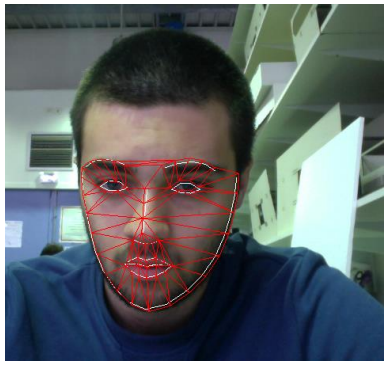
System's general architecture



* Natural Language Understanding
** Natural Language Generation

1. Deception detection: multi-modal

Hirschberg et.al (2005)



Pérez-Rosas et.al (2016)

pitch (F0)
energy

face AU* values
head direction
head position

classification

lie or **truth**?

* face AU: Face Action Unit (Eckman, 1978)

1. Classification using Multi Layer Perceptron (MLP)

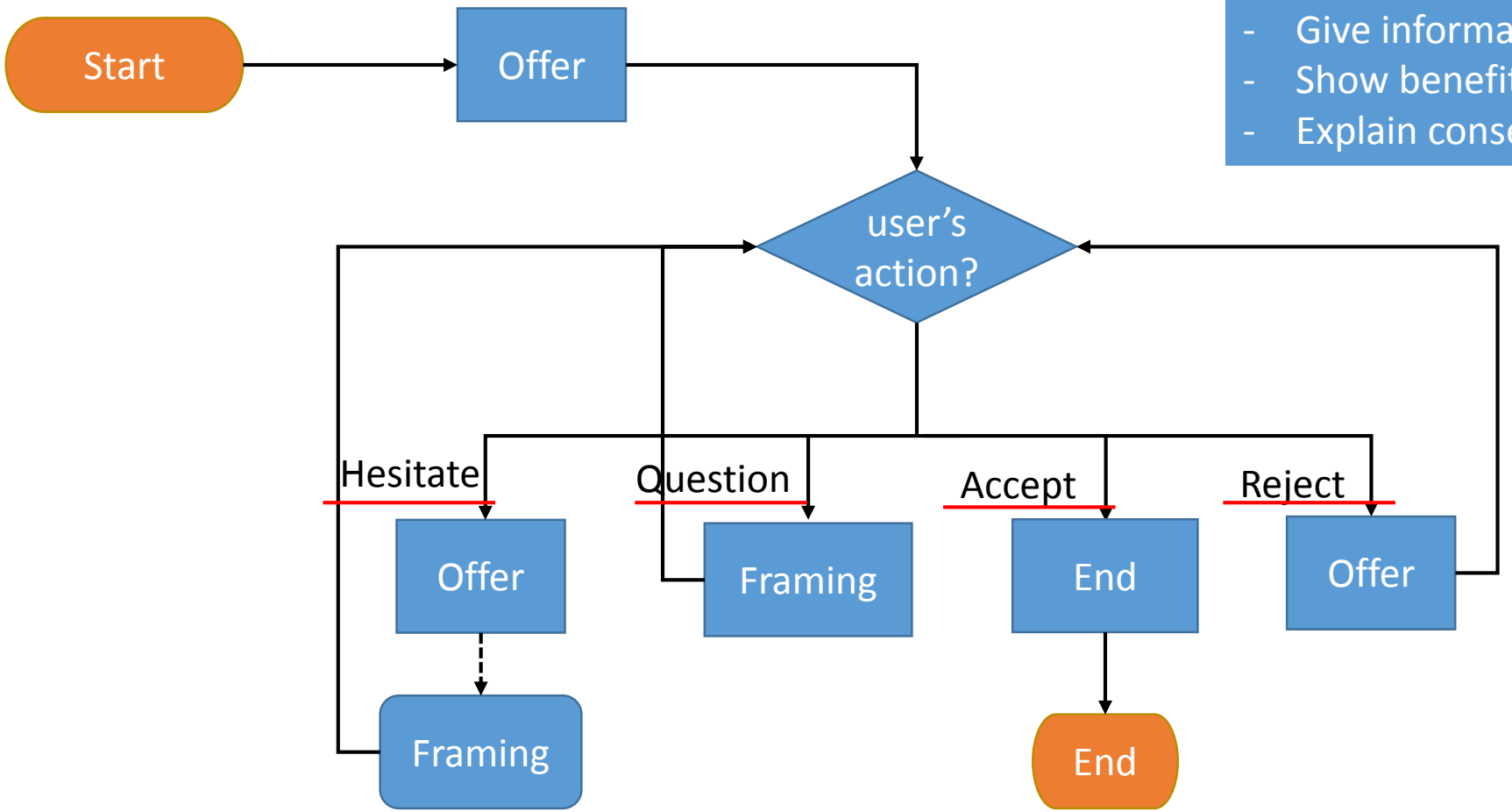
- MLP with single hidden layer, SGD, default Chainer parameters.
- 3 different models to combine facial and acoustic features: features-level, decision-level and hierachical (Tian et.al 2016).
- Hierarchical model accuracy is a bit higher than the others.

Combination model	Features-level	Decision-level	Hierachical
Accuracy	61.75%	58.83%	64.71%

→ **Cannot make an exact conclusion about user's deception**.

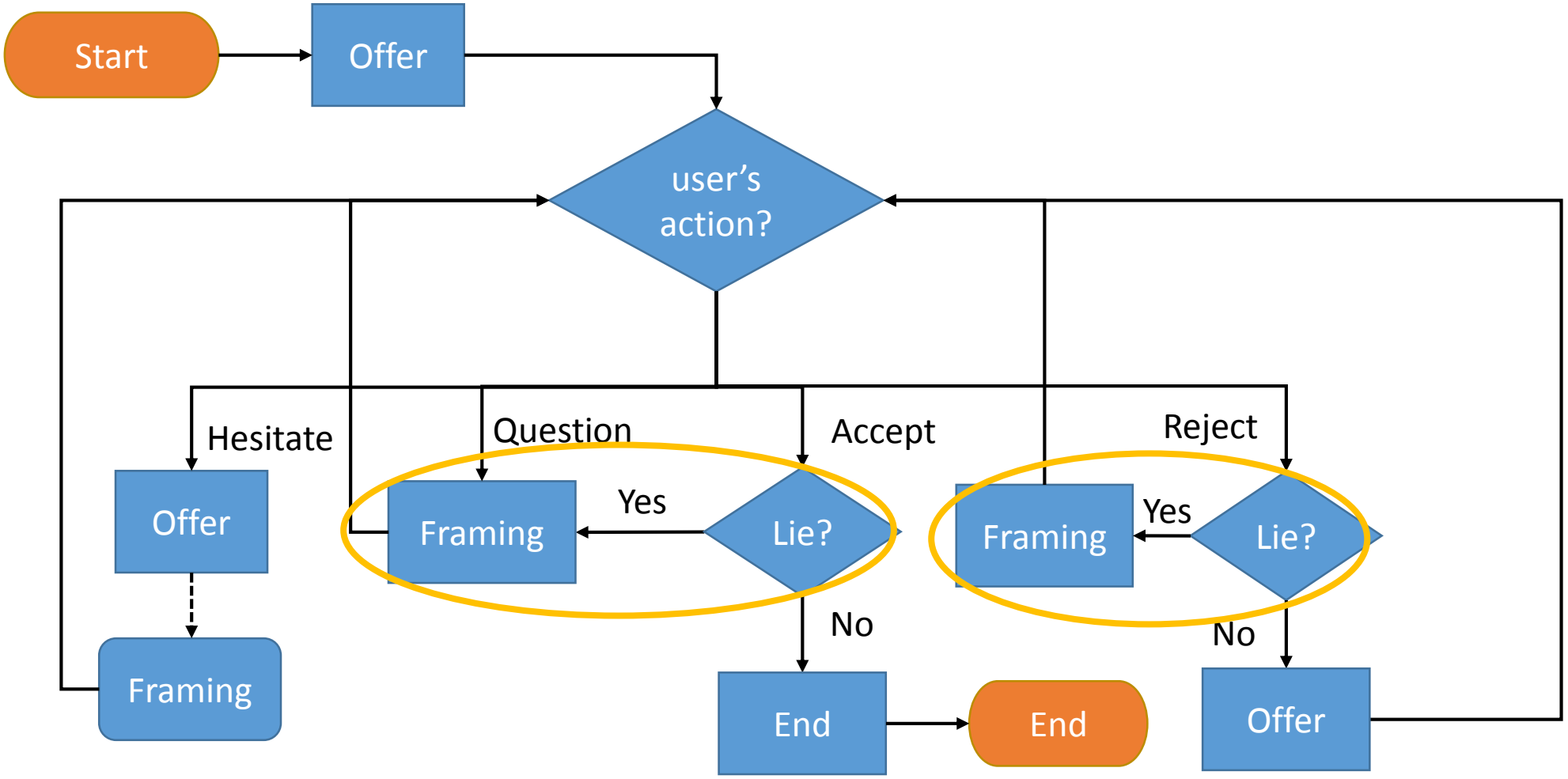
2. Baseline system's behavior

Framing:
- Give information
- Show benefits
- Explain consequences



Normal negotiation system reacts based on **user's action only**

2. Proposed system's behavior



System reacts based on **user's action + user's deception.**

3. Learning using POMDP+Reinforcement Learning

- System can only make **estimation of user's deception**.
- System reacts based on user dialog state, which consists of both **user's action** and **user's deception**.

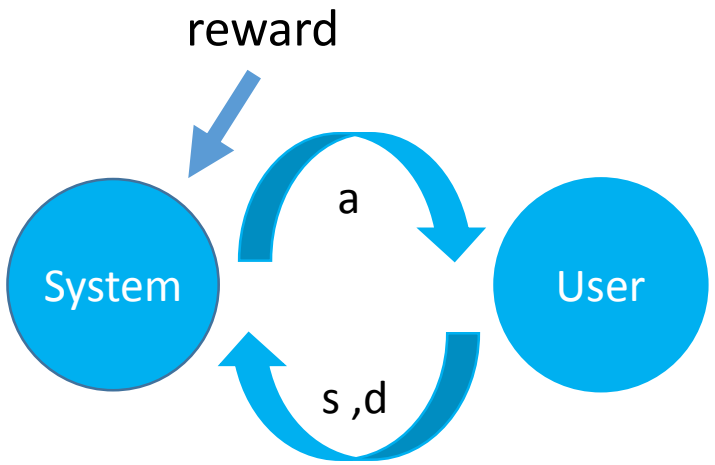
→ **Partially Observable Markov Decision Process was chosen.**

- **System learns by Reinforcement Learning (RL),** used in previous work (Georgilla & Traum, 2011.)
- Q-learning with grid-based Iteration method by Bonet (2002).
- State transition:

$$P(s^{t+1},d^{t+1}|s^t,d^t,\hat{a}^t) = \underbrace{P(s^{t+1}|d^{t+1},s^t,d^t,\hat{a}^t)}_{\text{intention model}}\underbrace{P(d^{t+1}|s^t,d^t,\hat{a}^t)}_{\text{deception model}}$$

s: use's dialog act
d: user's deception

3. Reward definition



Reinforcement Learning

Dialog state		Action a		
User action (s)	Deception (d) *	Offer	Framing	End
Accept	0	-10	-10	**+100**
	1	**-10**	**+10**	-100
Reject	0	+10	-10	-100
	1	**-10**	**+10**	-100
Question	0	-10	+10	-100
Hesitate	0	+10	+10	-100

*: 0 – honest
1 – deceptive

Using RL, system can learn the designed strategy while trying to successfully persuade the user.

Dialog corpus

Recorded using “changing living habits” scenario.

	Train	Test
Participants	7 participants 4 played system 6 played user	
Duration #of dialogs Avg. turns per dialog	3 hours 20 minutes 29 dialogs 5.72 turns/dialog	2 hrs 35 minutes 30 dialogs 4.73 turns/dialog
Record set up	Wizard-of-Oz	Direct conversation

- Trained using simulated user (Yoshino & Kawahara, 2015)
- Simulated user: generates dialog act and deception using probabilities calculated from Train data.
- Q-learning with learning rate: 0.1, discount factor: 0.9, exploration: 0.2 → 0.01; 100,000 dialogs.

Experiment #1: Against simulated user

Dialog system	% Success dialogs	Avg. offer per succeeded dialog
W/o deception (baseline)	21.83%	2.472
With deception (proposed)	**29.82%**	2.447

- Systems interacted with SU created from test data.
- % success dialogs: higher is better.
- Avg. offer per succeeded dialog: lower is better.

→ **proposed system behavior performs better.**

Experiment #2: System DA selection

Dialog system	System DA selection accuracy	Deception Handling *
Baseline	68.15%	35.00%
Proposed system (annotated deception)	**80.45%**	**80.00%**
Proposed system (predicted deception)	**79.32%**	**55.00%**

* System DA selection accuracy on the turns when user is lying

- Evaluate turn-by-turn
- Human expert selects best reaction in each dialog turn (based on annotated user's action and user's deception)
- Accuracy is measure by comparing system's choice with human choice for each dialog turn.

→ **proposed system performs better.**

Conclusion

Conclusion:

- In this work, we investigated the problem of lying in negotiation using the Doctor-Patient conversation.
- Proposed a dialog system that detects user's lies and uses this information for dialog management.
- Evaluation results shows that proposed system outperforms normal negotiation system by 8% in term of negotiation success rate and 11% in term of system dialog act selection.

Future works:

- Use ASR (speech recognition) and NLG (sentence generation) technology.
- Evaluation with human user.

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3. Grid-based iteration (appendix)

- Infinite number of belief states which makes the problem intractable.
- Grid-based Iteration method by Bonet (2002):

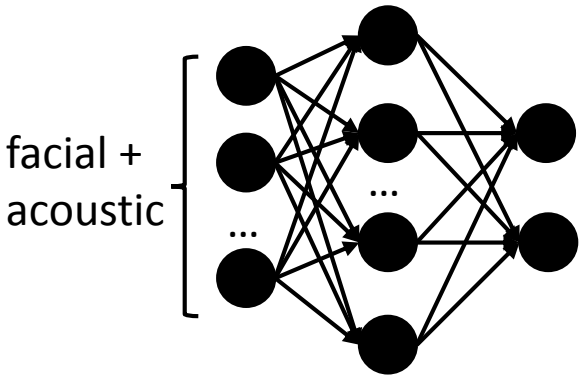
$$b_{s_i} = \begin{cases} \mu & \text{if } s = o \\ \frac{1-\mu}{|S|-1} & \text{otherwise} \end{cases}$$

- The probabilities are quantized into {0.0, 0.1 … 1.0}

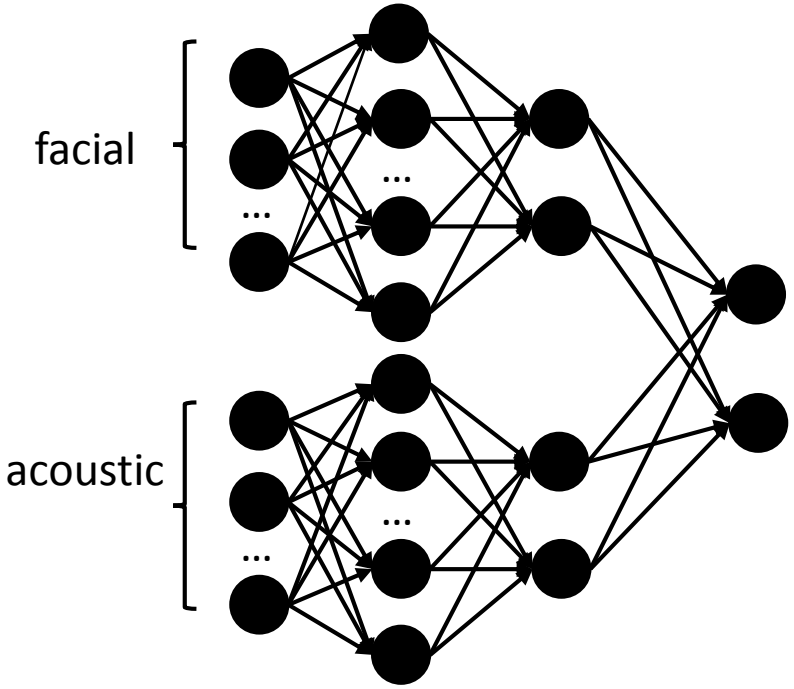
$$b = (\{A: 0.147, H: 0.386, Q: 0.235, R: 0.232\}, \{L: 0.735, T: 0.265\})$$

$$\rightarrow b' = (\{A: 0.2, H: 0.4, Q: 0.2, R: 0.2\}, \{L: 0.7, T: 0.3\})$$

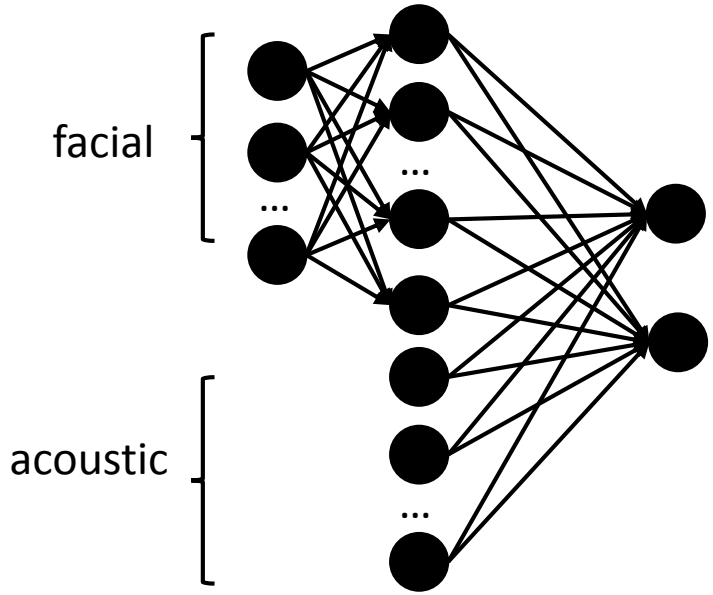
1. Classification using Multi Layer Perceptron (appendix)



features-level combination



decision-level combination



hierachical combination

Tian et.al (2016)