# Dialogue systems

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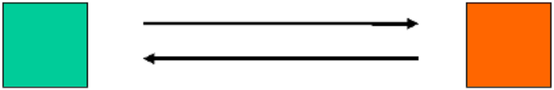
- Dialogue strategies and user model unification.
- Affective computing – emotion processing.
- Other research area compatibility:
  - the formal languages and automata theory
  - the game theory
  - the universal algebra
  - ...
- Allows to predict the dialogue flow.
- VoiceXML compatibility.

# Dialogue Mathematical Model

- Consists of:
  - two communicating parties.
  - their utterances that alternate.



# Pragmatics of Dialogue



- We analyse the dialogue from the point of view of:
  - speech act theory
  - lexical semantic a pragmatic
  - dynamic semantic
  - dynamic epistemic logic (cognition logic) – the utterance meaning may change through the time and speaker need not be sure for 100% with the content.
  - conversation theory.
- Pragmatic may contain next:
  - user(s) model(s)
  - environment model

# Dialogue Pragmatic

## Speech Acts Theory View



- speech act – action performed by language:
- Utterance: "It's 9 o'clock."
- Utterance pragmatic - Current time vs. It's too soon/too late and some action should be performed.

# Dialogue Pragmatic

## The View of Lexical Semantic and Pragmatic

- Lexical semantic - the meaning of utterance based on the other parts of the speech (words, . . . )
- Lexical pragmatic - the meaning of of the utterance in the context of the speech
  - previous utterances
  - non-verbal parts of communication
  - . . .

# Dialogue Pragmatic

## The Dynamic Semantic and The Dynamic Epistemic Logic View

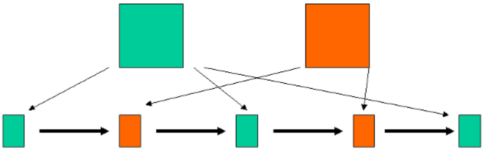
- Dynamic semantic
  - takes anaphora into the account (object referencing in the text: "I've seen it,")
  - the dynamics of meaning changes in discourse (Using the language to achieve the intended pragmatic meaning, the speaker utterance in the meaning of the dialogue) initiated by the gradual exposure of anaphora.
- Dynamic epistemic logic – cognition logic:
  - the truthfulness of a proposition is developing through the time,
  - the speaker need not to be sure for 100%.

# Dialogue Pragmatic

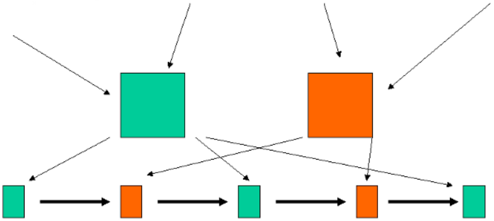
## Example



- The pragmatic containing the models of users:



- The pragmatic containing the models of users and the environment:



# Dialogue Simulation by Pawlak's Information System



- Pawlak's IS $S = (X, T, V, f)$:
  - $X$ – set of IS objects.
  - $T$ – set of objects attributes.
  - $V$ – set of attributes values.

$$f : X \times T \rightarrow V$$

- Example – trading on the market:
  - Attributes:
    - proposed price: -, 1 — 1000
    - non-verbal attitude: :-), :–, :-(, :->
  - Possible dialogue flow: (1000, :-)), *(500, :–)*, (900, :-)), *(600, :-()*, (800,:–), *(-,:->)*, (700, :-(), *(700,:-))*

# Dialogue Modelling

## Mealy Automaton

- Mealy automaton $M$ – finite state automaton with output.
- $M = (Q, X, Y, \lambda, s_0)$
  - Q – non-empty set of states
  - X – finite input alphabet
  - Y – finite output alphabet
  - $\lambda$ – transition function:

$$\lambda : Q \times X \to Q \times Y$$

  - $s_0$ – initial state.

# User Modelling

## Poker

- Poker is a card game where the player bet on their cards.
- Basic rules:
  1. Banker, the person who is handing cards, deals 5 cards to each player.
  2. Players based on the cards in their hand can:
     - bet money with possibility of exchange the cards that don't suite them and either to call or to increase the bet.
     - fold the cards.
  3. As soon as no one raise the bet (call/fold) the game is over. The game is over in the case when only one player doesn't fold. The player with highest cards wins the entire staked money.

# Poker
## Continue



- This game has a lot of variants..
- When player use a good strategy he may win although his cards are bad:
  - minimization of non-verbal expressions
  - well chosen strategy of raising, that gives the impression that cards are very good
  - avoiding similar strategy in the following games – the other players shouldn't be able to observe players common behaviour features in some situations.

# Poker

## Finite State Analysis alà dialogue

- Game's state attributes (sets $A_s$):
  - $AS_1$ – my cards
  - $AS_2$ – the total amount of the bet
  - $AS_3$ – trust in own cards
  - $AS_4$ – expected opponent's cards
  - $AS_5$ – player's strategy

# Poker

## Game State Attributes Values



- my cards – $AS_1 \in \{bad, medium, good\}$
- the total amount of the bet – $AS_2 \in \{high, medium, low\}$
- trust in own cards – $AS_3 \in \{high, medium, low\}$
- opponent's cards – $AS_4 \in \{bad, medium, good\}$
- player's strategy – $AS_5 \in \{careful, risky, bluffing\}$.

# Poker

## Dialogue Utterances Attributes ($A_x$ Sets)

- choice – $AX_1 \in \{call, rise, fold\}$
- speech self-confidence – $AX_2 \in \{high, medium, low\}$
- speech credibility – $AX_3 \in \{high, medium, low\}$
- voice excitement – $AX_4 \in \{high, medium, low\}$

# Poker

## Inner States Fragment

| State | my cards | total amount of bet | trust in own cards | opponent cards | player strategy |
|---|---|---|---|---|---|
| $S_1$ | medium | high | medium | medium | careful |
| $S_2$ | medium | high | high | medium | risky |
| $S_3$ | high | high | medium | medium | risky |
| $S_4$ | high | high | medium | medium | bluffing |
| $S_5$ | bad | low | medium | low | risky |
| $S_6$ | bad | low | low | medium | careful |
| $S_7$ | good | medium | medium | medium | risky |
| $S_8$ | good | medium | low | good | careful |

# Poker

## Dialogue Utterances Fragment

| Utterance | $AX_1$ (choice) | $AX_2$ (self-confidence) | $AX_3$ (credibility) | $AX_4$ (exciteme |
|---|---|---|---|---|
| $x_1$ | raise | high | low | high |
| $x_2$ | raise | high | high | low |
| $x_3$ | call | low | high | mediur |
| $x_4$ | raise | high | medium | low |
| $x_5$ | fold | low | high | low |
| $x_6$ | call | low | high | mediur |

# Poker

## Dialogue Strategies Examples



- Experienced player:
  - state $S_1$ = (medium own cards, high bet, medium own cards trust, expected medium opponent cards, careful strategy), utterance $X_1$=(raise, high self-confidence, low credibility, high excitement in voice):

$$\delta(S_1, X_1) = S_2, \lambda(S_1, X_1) = X_2$$

  - State $S_3$= (good own cards, high bet, medium own cards trust, expected medium opponent cards, careful strategy), utterance$X1$:

$$\delta(S_3, X_1) = S_4, \lambda(S_3, X_1) = X_3$$

# Poker

## Finish

- Rookie:
  - state $S_5$ = (bad cards, low bet, medium own card trust, expects bad opponents cards, risky strategy), utterance $X_4$ = (rise, high self-confidence, high credibility, low excitement)

$$\delta(S_5, X_4) = S_2, \lambda(S_5, X_4) = X_5$$

  - state $S_7$ = (good cards, medium bet, medium own card trust, expects medium opponent's cards, risky strategy), utterance $X_4$=(rise, high self-confidence, medium credibility, low excitement)

$$\delta(S_7, X_4) = S_8, \lambda(S_7, X_4) = X_6$$

# Dialogue and Strategy Games



- Dialogue can be considered a strategic game.
- Strategic game contains set of players.
- Every player has a set of actions (strategies).
- Every player has a preferential session — pay-off function.

# Strategic games

## Prisoner's dilemma



- Two players strategic game.
- Presumes that every player cares about its own benefit.
- Simulates crime investigation, where are two suspected.
- Rules:
  1. When both prisoners do not testify they're convicted of another minor crime to a shorter sentence (2 years for example).
  2. If one prisoner plead guilty, he is freed and the other one is sentenced to a maximum penalty(10 years).
  3. If both plead guilty, they are both sentenced to a half penalty (5 years).
- Prisoner's dilemma – What will select the partner?

# Hawk-Dove Attitude

| | dove | hawk |
|---|---|---|
| dove | 5, 5 | 0, 10 |
| hawk | 10, 0 | 2, 2 |

# Similar Pay-off Function Strategic Games



- War of sexes
  - Spouses prefer to spend the time together. What will we do on today's afternoon? Will we visit (watch) a fashion show or a football game?
- Eagle – Head Game
  - Two people bet what will be on a coin? An eagle or a head?

# Iterated Strategy Games



- The player plays a strategy game repeatedly.
- It forms extensive game with a perfect knowledge.
  - Extensive game – repeating game.
  - Perfect knowledge – you know all players move history.
- Examples:
  - iterated prisoner's dilemma
  - iterated game "War of Sexes".

# Iterated Prisoner's Dilemma

## Strategy

- Always cooperate – always plead guilty regardless of how the team-mate behaved before (naive peacemaker).
- Always betray – always deny.
- Tit-for-tat – cooperate or not cooperate according the co-accused cooperated or not in the previous iteration.
- Malicious – cooperates since the co-accused doesn't betray him. Always betray from that moment.
- Mistrust – first betrays and then repeats the last co-accused move.
- Pavlov – cooperates only when the co-accused cooperated in the previous iteration.
- Hard Tit-for-tat – cooperates when co-accused didn't betrayed in any of the two previous iterations.
- Random – cooperates with probability 0.5.

# Iterated Space Prisoner's Dilemma



- Objects (cells, individuals, players) plays iterated prisoner's dilemma with its neighbours.
- The objects change their strategy for next round according the result of the round.
- Colony behaviour is an undicidable problem.
  - Proven– P. Grim 1994.

# Strategy Games Applications



- Economy – market behaviour, customers behaviour, . . .
- Sociology
- Psychology
- Policy
    - strategic decisions in the interest of the state.
- Ecology
- . . .

# Corpus Based Dialogue Interface Generating

- We can automatically generate the dialogue interface that "corresponds" to the corpus data.
- Algorithm:
  1. Lets create corpus using the Wizard of Oz method (works only the "wizard")
  2. We remove the conflicts from the corpus.
  3. We create new corpus combined way ("wizard" tries to use the proposed dialogue interface as much as possible).
  4. We remove the conflicts and we generate new dialogue interface.
  5. When the interface is O.K. we finish. We continue the step number 3 otherwise.