Conceptual Dependency

-A Model of Natural Language understanding in Artificial Intelligence
-Represent knowledge acquire from NL input

Conceptual Dependency (CD)

- CD theory was developed by Schank in 1973 to 1975 to represent the meaning of NL sentences.
  - It helps in drawing inferences
  - It is independent of the language
- CD representation of a sentence is not built using words in the sentence rather built using conceptual primitives which give the intended meanings of words.
- CD provides **structures** and specific **set of primitives** from which representation can be built.

Primitive Acts of CD theory

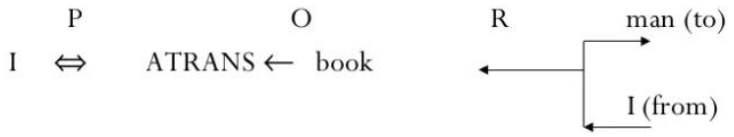
• ATRANS	Transfer of an abstract relationship (i.e. give)
• PTRANS	Transfer of the physical location of an object (e.g., go)
• PROPEL	Application of physical force to an object (e.g. push)
• MOVE	Movement of a body part by its owner (e.g. kick)
• GRASP	Grasping of an object by an action (e.g. throw)
• INGEST	Ingesting of an object by an animal (e.g. eat)
• EXPEL	Expulsion of something from the body of an animal (e.g. cry)
• MTRANS	Transfer of mental information (e.g. tell)
• MBUILD	Building new information out of old (e.g decide)
• SPEAK	Producing of sounds (e.g. say)
• ATTEND	Focusing of a sense organ toward a stimulus (e.g. listen)

Conceptual category

- There are four conceptual categories
  - ACT Actions {one of the CD primitives}
  - PP Objects {picture producers}
  - AA Modifiers of actions {action aiders}
  - PA Modifiers of PP's {picture aiders}

Example

- I gave a book to the man. CD representation is as follows:



- It should be noted that this representation is same for different saying with same meaning. For example
  - I gave the man a book,
  - The man got book from me,
  - The book was given to man by me etc.

Few conventions

- Arrows indicate directions of dependency
- Double arrow indicates two way link between actor and action.

  O – for the object case relation

  R – for the recipient case relation

  P – for past tense

  D - destination

- The use of tense and mood in describing events is extremely important and schank introduced the following modifiers:
- **p**– past
- **f**– future
- **t**– Transition
- **t_s**-start Transition
- **t_f**-Finished Transition
- **k** -Continuing
- **? I**nterrogative
- **/** Negative
- Nil-Present
- **delta**– timeless
- **c**– conditional
- The absence of any modifier implies the *present tense*.

Rule 1: PP ⇔ ACT

- It describes the relationship between an actor and the event he or she causes.
  - This is a two-way dependency, since neither actor nor event can be considered primary.
  - The letter P in the dependency link indicates past tense.
- Example: John ran

P

CD Rep: John ⇔ PTRANS

Rule 2: ACT ← PP

- It describes the relationship between a ACT and a PP (object) of ACT.
  - The direction of the arrow is toward the ACT since the context of the specific ACT determines the meaning of the object relation.

- Example: John pushed the bike

CD Rep: John ⇔ PROPEL ←(o) bike

Rule 3: PP ↔ PP

- It describes the relationship between two PP's, one of which belongs to the set defined by the other.

- Example: John is doctor

CD Rep: John ↔ doctor

Rule 4: PP ← PP

- It describes the relationship between two PP's, one of which provides a particular kind of information about the other.
  - The three most common types of information to be provided in this way are possession (shown as POSS-BY), location (shown as LOC), and physical containment (shown as CONT).
  - The direction of the arrow is again toward the concept being described.

- Example: John's dog

CD Rep dog ←(poss-by) John

Rule 5: PP ⇔ PA

- It describes the relationship between a PP and a PA that is asserted to describe it.
  - PA represents states of PP such as height, health etc.

- Example: John is fat

CD Rep John ⇔ weight (> 80)

Rule 6: PP ← PA

- It describes the relationship between a PP and an attribute that already has been predicated of it.
  - Direction is towards PP being described.

- Example: Smart John

CD Rep John ← smart

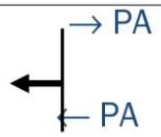
Rule 7: ACT ← R → PP (to)
← PP (from)

- It describes the relationship between an ACT and the source and the recipient of the ACT

- Example: John took the book from Mary

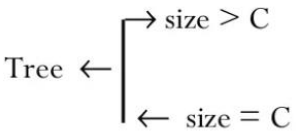
CD Rep: John ⇔ ATRANS ← R → John
o ↑ ← Mary
book

Rule 8:

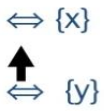


- It describes the relationship that describes the change in state.
- Example: Tree grows

CD Rep:



Rule 9:

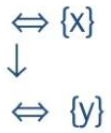


- It describes the relationship between one conceptualization and another that causes it.
  - Here {x} is causes {y} i.e., if x then y
- Example: Bill shot Bob

  {x} : Bill shot Bob

  {y} : Bob's health is poor

Rule 10:



- It describes the relationship between one conceptualization with another that is happening at the time of the first.
  - Here {y} is happening while {x} is in progress.
- Example: While going home I saw a snake

  I am going home

  ↓

  I saw a snake

Generation of CD representations

Sentences	CD Representations
Jenny cried	p o d ? Jenny ⇔ EXPEL ← tears eyes poss-by ⇑ Jenny
Mike went to India	p d India Mike ⇔ PTRANS ? (source is unknown)
Mary read a novel	p o d CP(Mary) Mary ⇔ MTRANS ← info novel ↑ i (instrument) p o d novel Mary ⇔ ATTEND ← eyes ?

- *Primitive states* are used to describe many state descriptions such as height, health, mental state, physical state.
- There are many more physical states than primitive actions. They use a numeric scale.
- *E.g.* John height(+10) *John is the tallest*
- John height(< average) *John is short*
- Frank Zappa health(-10) *Frank Zappa is dead*
- Dave mental_state(-10) *Dave is sad*
- Vase physical_state(-10) *The vase is broken*
-

Sentence	CD Representation
Since drugs can kill, I stopped.	o r One One ⇔ INGEST ← durgs Mouth c health = -10 One health > -10 c t_{fp} o r I I ⇔ INGEST ← durgs mouth

Inferences Associated with Primitive Act

- General inferences are stored with each primitive Act thus reducing the number of inferences that need to be stored explicitly with each concept.
- For example, from a sentence "John killed Mike", we can infer that "Mike is dead".
- Let us take another example of primitive Act INGEST.
- The following inferences can be associated with it.
  - The object ingested is no longer available in its original form.
  - If object is eatable, then the actor has less hunger.
  - If object is toxic, then the actor's heath is bad.
  - The physical position of object has changed. So PTRANS is inferred.

Cont...

- Example: The verbs {give, take, steal, donate} involve a transfer of ownership of an object.
  - If any of them occurs, then inferences about who now has the object and who once had the object may be important.
  - In a CD representation, these possible inferences can be stated once and associated with the primitive ACT "ATRANS".
- Consider another sentence "Bill threatened John with a broken nose"
  - Sentence interpretation is that Bill informed John that he (Bill) will do something to break john's nose.
  - Bill did (said) so in order that John will believe that if he (john) does some other thing (different from what Bill wanted) then Bill will break John's nose.

Problems with CD Representation

- It is difficult to
  - construct original sentence from its corresponding CD representation.
  - CD representation can be used as a general model for knowledge representation, because this theory is based on representation of events as well as all the information related to events.
- Rules are to be carefully designed for each primitive action in order to obtain semantically correct interpretation.

Advantages of CD:

- Using these primitives involves fewer inference rules.
- Many inference rules are already represented in CD structure.
- The holes in the initial structure help to focus on the points still to be established.

Disadvantages of CD:

- Knowledge must be decomposed into fairly low level primitives.
- Impossible or difficult to find correct set of primitives.
- A lot of inference may still be required.
- Representations can be complex even for relatively simple actions. Consider: *Dave bet Frank five pounds that Wales would win the Rugby World Cup*.
- Complex representations require a lot of storage

APPLICATIONS OF CD:

- **MARGIE**(*Meaning Analysis, Response Generation and Inference on English*) -- model natural language understanding.
- **SAM**(*Script Applier Mechanism*) -- Scripts to understand stories.
- **PAM**(*Plan Applier Mechanism*) -- Scripts to understand stories.