Nuance:

A Complex Network of Concepts

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Nuance: A Complex Network of Concepts

1. Introduction
2. Prototype Model
3. Preliminary Results
4. Discussion

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1. Introduction
   - Motivation: From Symbols to Meaning
   - Denotation and Connotation
   - A Linguistic Model of Cognition
2. Prototype Model
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1. Introduction

➢ Motivation: From Symbols to Meaning

- ✓ unraveling how language correlates with the mind's conceptual organization is a core challenge of cognitive science and AI
  - natural language processing/translation
  - human-computer interaction
  - text information retrieval
  - conceptual Web search
- ✓ common-knowledge associations, e.g., between 'throw' and 'ball', are not found in dictionaries
- ✓ yet, they reveal our fundamental cognitive frames of reference (a.k.a. semantic fields, stereotypes, scenarios, etc.)

→ *how can we capture, model and use these frames?*

1. Introduction

➢ Denotation and Connotation

(1) It was a dark and stormy night

- ✓ what does this sentence *mean*? (denotation)
  - dark = little light
  - stormy = rain, lightning, thunder
  - night = no sun
- ✓ what other meaning does this sentence convey? (connotation)
  - fear, apprehension, suspense
  - violence, tumult
- ✓ where does this extra meaning come from?
  - cognitive frames of reference, themselves created by:
  - real-world, nonlinguistic experience (perception and action)
  - linguistic experience (written and oral)

1. Introduction

➢ A Linguistic Model of Cognition

- ✓ how can we simulate frames of reference?
- ✓ one way is cognitive linguistic, linking language with perception
  - nonlinguistic, iconic representations: visual scenes, etc.
- ✓ another way would be trying to infer frames of reference from purely **linguistic usage**
  - statistical co-occurrence of words in fully formed written text and spoken language: how often/strongly words are related
  - the whole written record of human experience is now almost entirely accessible via Internet

→ *opens the way to automated statistical parsing on a big scale*

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1. Introduction
2. Prototype Model
   - From Text Corpora to Word Clusters to Concepts
   - A Network-Database of Cluster-Concepts
   - Creating the Network: Nodes and Links
   - Querying the Network
3. Preliminary Results
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2. Prototype Model

➢ From Word Clusters to Concepts

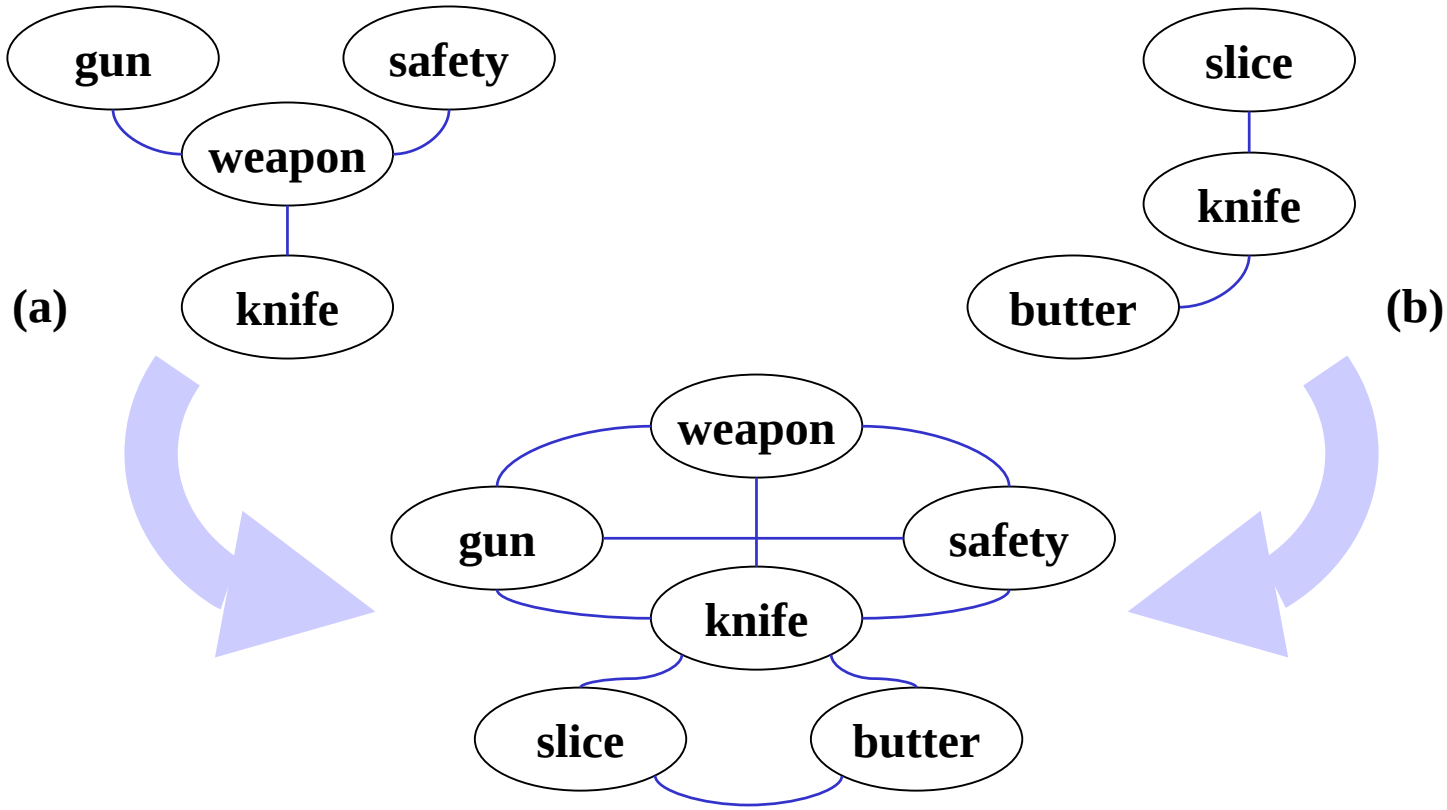
- ✓ the model is based on the premise that **concepts** are best captured by **word clusters** instead of single words
- ✓ a single word can belong to the intersection of several clusters representing different concepts
  - homonyms
    - game: chess, play, cards, tv, snacks, …
    - game: hunt, animal, wild, rifle, …
  - different usages
    - game: chess, play, cards, tv, snacks, …
    - game: joke, psychology, scheme, social, …
  - nuances
    - game: chess, play, cards, tv, snacks, …
    - game: competition, baseball, sports, tv, snacks, …

2. Prototype Model

➢ From Text Corpora to Word Clusters

(a) For your safety, no knife, gun, or other weapon is allowed

(b) A knife can slice through butter



2. Prototype Model

➢ A Network-Database of Cluster-Concepts

- ✓ we exploit the combinatorial power of networks to express semantic and cognitive concepts as supra-word entities
- ✓ we propose an algorithm to create a network-database of such word clusters by scanning and merging text corpora
- ✓ then, the network-database can be queried to retrieve cluster-concepts by selectively activating some of their nodes
- ✓ there is no predefined list of cluster-concepts: new word combinations might emerge from the connectivity of the network, depending on the input query

2. Prototype Model

➢ Creating the Network — Nodes

- ✓ when scanning the text, the system records the words encountered in the text and their location
  - if the word does not have a node, create a new node
  - add the location or “address” of the word to a list of addresses maintained by the word’s node
  - a word address is hierarchical, for example a quintuplet: *{document, section, paragraph, sentence, rank within sentence}*

2. Prototype Model

➢ Creating the Network — Nodes

Don't Call It Negotiating

You need not give up on a debt-free life. **Students** or their parents should phone or visit the aid office and request an appeal of their financial aid offer if they believe the initial offer does not meet their needs. . .

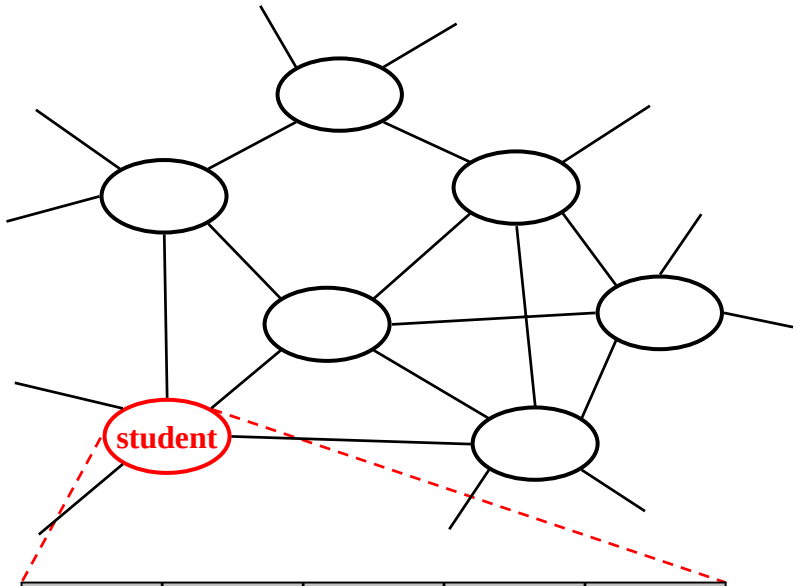
The Cost of College

By a **student**'s senior year of high school, most parents are struggling to save up any extra cash for college. . .

1. Test prep

Earning a certain AP test score may allow a **student** to get college credit and bypass some freshman classes. . .

Then there's the SAT. It's up in cost this year from $29.50 to $41.50, largely because it now includes a writing component. About half of **students** now take the SAT more than once. . .



doc	sect	parag	sent	rank
1	1	1	2	1
2	1	1	1	3
2	2	1	1	10
2	2	2	3	4

2. Prototype Model

➢ Creating the Network — Links

- ✓ the system then creates links between all nodes as follows:
  - given a pair of nodes, compare each address of the first word to each address of the second word
  - the distance between two word addresses is the compound effect of 5 factors, one factor for each level of the hierarchy
    - if the two addresses are in the same document, multiply by 1.01, otherwise by .8
    - if the two addresses are in the same section, multiply by 1.02, otherwise by .85
    - for same paragraph: × 1.05, otherwise .9
    - for same sentence: × 1.2, otherwise .95
    - if the two words are adjacent: × 1.5, otherwise .99

2. Prototype Model

➢ Creating the Network — Links

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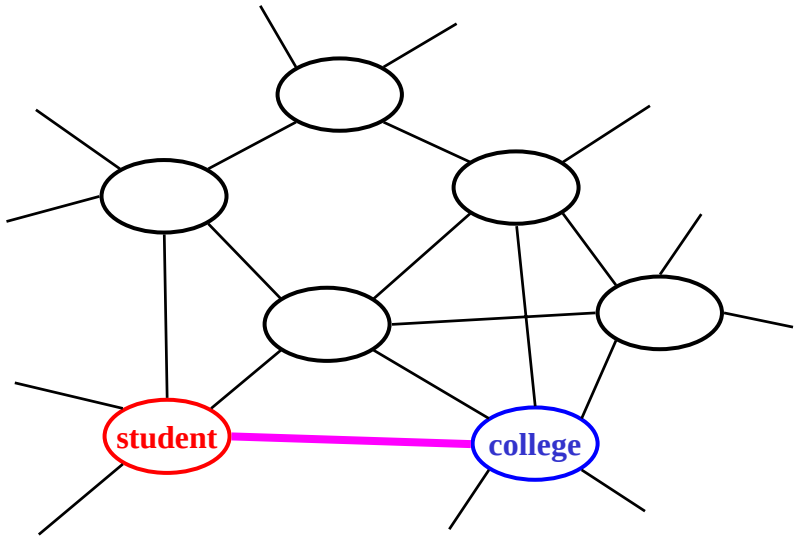


doc	sect	parag	sent	rank
2	2	1	1	10
× 1.01	× .85	[× .9	× .95	× .99] = .73
2	1	1	1	21
2	2	1	1	13
× 1.01	× 1.02	× 1.05	× 1.2	× .99 = 1.29

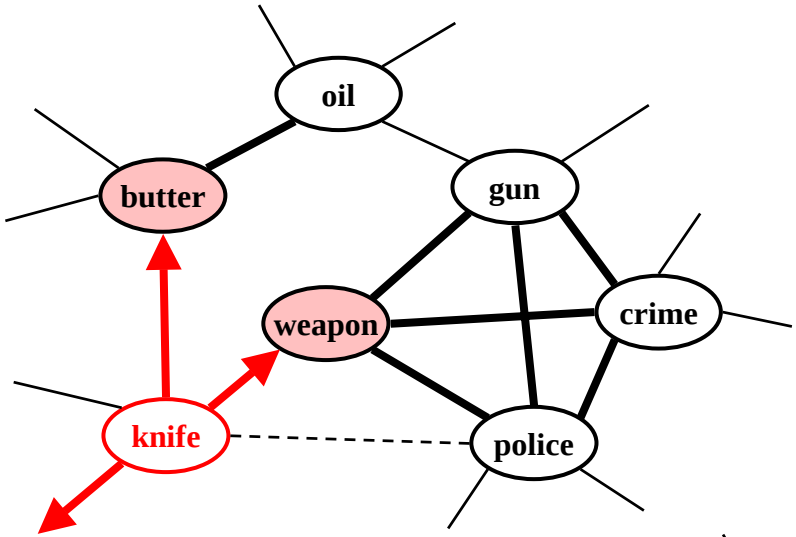
2. Prototype Model

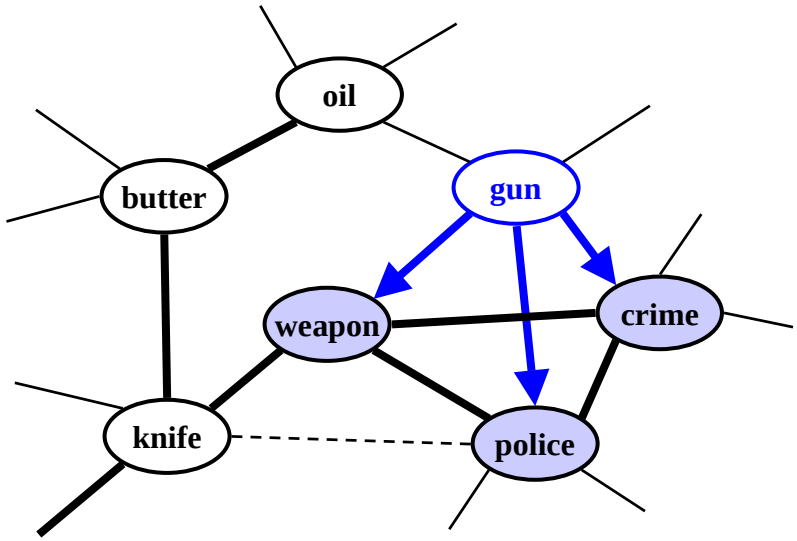
➢ Querying the Network

- ✓ the user may examine connected portions of the network by inputting queries
  - for now, a query is simply a list of words
- ✓ the system replies with output concepts
  - for now, a concept is also a list of words representing the cluster that was activated in the network by the query words
  - each query word activates the N words (e.g., 20) to which it is most strongly connected—its "preferred neighborhood"
  - the resulting concept words are at the intersection of all the preferred neighborhoods of the query words

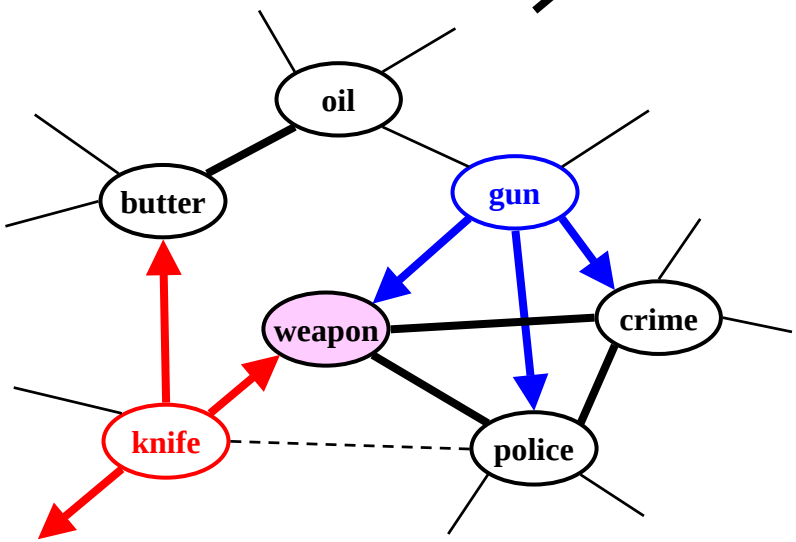
2. Prototype Model

- Querying the Network





knife, gun



knife, gun, weapon

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   - A Simple Command-Line Program (Demo)
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3. Preliminary Results

- A Simple Command-Line Program (Demo)
  - ✓ processing an input text
  - ✓ looking at the result file listing all the words and their links
  - ✓ querying the network with a few words
  - ✓ getting the output cluster-concepts

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➢ (Immediate) Future Directions

- ✓ integrating truly large text corpora, using a Web crawler
- ✓ exploration of model rules
  - network building: weight computation schemes
  - network querying: cluster activation schemes
- ✓ exploration of parameter space, self-tuning, optimization
- ✓ network structure analysis using complexity metrics: clustering coefficient, average path length, power law exponent, etc.

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