RADICAL: Radiology Content Alignment

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Abstract

RADICAL is a software system that analyzes groups of radiologists’ dictated medical reports, identifies implicit structural similarities, and converts these patterns into templates for radiologists to use when dictating future reports.

Goals

Derive radiological templates in order to...
- Reduce errors in radiological reports
- Improve productivity of medical professionals
- Improve Automatic Speech Recognition software
- Allow for efficient Automatic Data Extraction for use with electronic medical records

System Design

RADICAL takes an inputs a group of radiological reports to be aligned.

Groups the reports according to similarity by pairwise aligning every possible pair, resulting in a distance matrix.

This matrix is converted into a tree (reports are clustered by similarity) that determines the order in which reports are aligned.

Traversal the tree, building up a central alignment. When a certain threshold is reached, a template is output.

The system outputs a template and the underlying alignment of the reports.

Alignment Process

Pairwise Alignment

Needleman-Wunsch Algorithm

Dynamic Programming - computes OPTIMAL (highest-scoring) alignment by maximizing Alignment Score based on a given cost function.

Cost Function:
- +5 for match
- -4 for mismatch
- -3 for deletion

Template Symbols:
- * for slot (1-3 words)
- . . . for gap (4+ words)

Example:
Report 1: There is some evidence of fracture in the scan results.
Report 2: There is no evidence of a fracture to his femur.

Template: There is * evidence of * fracture (gap)

Multiple Sequence Alignment

Feng-Doolittle Algorithm

Greedy - makes decisions based on what is best locally at each step, may yield SUB-OPTIMAL overall results.

Builds a central alignment through multiple pairwise alignments, starting with most similar reports and progressively adding new reports, pairwise alignment with each report in the growing MSA.

Alignment is ordered according to a phylogenetic Guide Tree.

Evaluation

Templates created by RADICAL are evaluated in two ways:
- Medical Relevance - subjective evaluation of whether the template would be useful for use in the real world.
- Technical Metrics - objective. Template length, number of slots/gaps, how many reports it covers.
- Precision - measures the average percentage of the report that is covered by the template.
- Recall - measures how many of the reports used to generate the template exactly match it.

There is a tradeoff between Precision and Recall...

Sample Template

The following sample is taken from a series of gynecological check-ups of pregnant women.

Reports:
- Avg. Report Length: 243 words
- Template Length: 167 words

Template Excerpt:
Impression: Single live intrauterine gestation at approximately * weeks * days. Comment: Ultrasound examination of the gravid uterus was performed. The patient retains ... date of .. which projects to a current gestational age of * There is a single fetus identified in a * lies. The head circumference measures * cm * weeks * days. There are no cut de sac adnexal or cervical changes identified ...

Example Slot Fillers:

0: "then" 1: "sat" 2: "et al" 3: "common" 4: "uncommon" 5: "none" 6: "variation" 7: "breach"

Mispellings Numbers Optional Words Limited Choice

Sub-Templates

Conclusions

At least in some subfields of radiology, significant implicit structure exists and templates can be found.

Hospitals must now be convinced to begin migrating toward use of standardized reporting templates.

Further exploration is needed to find useful applications for our observations (slot fillers, etc.)

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