The Evolution of MetaMap, A Concept Search Program for Biomedical Text

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Outline

- Background
  - Mapping programs
  - MetaMap distribution modes
  - Applications using MetaMap
- Recent MetaMap development
  - Tokenization issues
  - Output formats
  - Genre and task issues
  - Algorithm tuning
Historical Background

- Programs that map biomedical text to a thesaurus
  - CLARIT (*Evans et al., 1991*)
  - SAPHIRE (*Hersh et al., 1990*)
  - MetaMap (*Aronson et al., 1994*)
  - Metaphrase (*Tuttle et al., 1998*)
  - MMTx (*2001*)
  - KnowledgeMap (*Denny et al., 2003*)
  - Mgrep (*2009*)

- Characteristics of MetaMap/MMTx
  - Linguistic rigor
  - Flexible partial matching
  - Emphasis on thoroughness rather than speed
MetaMap Example

- PMID – 19529903

- TI – *Bile duct stricture* due to *caused* by *portal*
  
  Stricture of bile duct  
  Causing  
  Hepatic

biliopathy: *Treatment* with *one-stage*

  Administration procedure  
  One  
  Phase

*portal-systemic shunt* and *biliary bypass*.

  Portasystemic shunt  
  Biliary  
  Bypass
MetaMap/MMTTx Distribution Modes

MetaMap is a highly configurable program developed by Dr. Alan (Lan) Aronson at the National Library of Medicine (NLM) to map biomedical text to the UMLS Metathesaurus, or, equivalently, to discover Metathesaurus concepts referred to in text. MetaMap uses a knowledge-intensive approach based on symbolic, natural language processing (NLP) and computational linguistic techniques. Besides being applied for both IR and data mining applications, MetaMap is one of the foundations of NLM’s Medical Text Indexer (MTI) which is being applied to both semiautomatic and fully automatic indexing of biomedical literature at NLM.

**Avenues to MetaMap:**

**Web Access**
- Our Semantic Knowledge Representation (SKR) website provides both Interactive and Batch facilities that allow users to send text to our internal machines and run various programs including the MetaMap program.
- The Interactive facility is designed for testing options and running small amounts of text. The Batch facility runs large amounts of text through our Scheduler program which distributes the workload over a large pool of clients.

**MetaMap**
- Distribution version of the original Prolog MetaMap program. Currently only includes binary distribution for Solaris and Linux platforms.
- SKR API: Java-based API to the SKR Scheduler facility was created to provide users with the ability to programmatically submit jobs to the Scheduler Interactive and Batch facilities instead of using the web-based interfaces. We have tried to reproduce full functionality for all the programs under the SKR Scheduler umbrella. The SKR API has been tested on the Solaris, Linux, and Windows XP platforms.

**NOTE:** MMTx is no longer supported except for major bug fixes. We recommend all users switch to the downloadable MetaMap (described above) if possible.

**MMTx**
- MetaMap Transfer (MMTx) is a java-based distributable version of the MetaMap program. Includes binary and source distributions and is supported on Solaris, Linux, Windows, and Mac platforms. MMTx was an early attempt at providing a distributable version of MetaMap and is currently being phased out in favor of the original Prolog version of MetaMap. There are two reasons for the phase out of MMTx: 1) The original Prolog version of MetaMap is much faster, especially now with the new speed enhancements (V2). 2) We were never able to make the results the same between MMTx and MetaMap - there was always about a 20% difference in the overall results MMTx would produce.


U. S. NATIONAL LIBRARY OF MEDICINE
### MetaMap/MMTx Distribution Modes

#### Avenues to MetaMap:

<table>
<thead>
<tr>
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NLM Applications using MetaMap

• Information retrieval (IR)
  • Indexing and query expansion experiments (Aronson et al., Rindflesch et al.)
  • Hierarchical indexing (Wright, Grosetta-Nardini, et al.)
  • TREC genomics track (Aronson et al., Demner-Fushman et al., ...)

• Data mining
  • DAD (Drug-Adverse drug reactions-Disease) literature-based discovery (Weeber et al.)
  • Clinical findings (Sneiderman et al.)
  • Arbiter, EDGAR, anatomical terminology, SemRep, SemGen (Rindflesch et al.)

• NLM Indexing Initiative (II)
  • Medical Text Indexer (MTI) (Aronson et al.)
  • MeSH indexing experiment (Kim, Aronson and Wilbur)
Tokenization Issues

• Acronym/abbreviation detection
  • e.g., “The effect of adrenocorticotropic hormone (ACTH) and cortisone on drug hypersensitivity reactions.”
  • Similar to Schwartz and Hearst, 2003 with rules:
    • AAs cannot contain > 20 characters
    • Single-word AAs cannot contain > 12 characters
    • …

• Non-standard input
  • e.g., several PubMed citations having no whitespace between sentences
Output Formats

- MetaMap Machine Output (MMO)
  - Prolog terms
  - Used for subsequent processing
- XML output
- Colorized MetaMap output (MetaMap 3D)
MetaMap 3D

PMID: 11070566
OWN - NLM
STAT - MEDLINE
DA - 20001120
DCOM - 20001120
LR - 200070214
PUBM - Print
IS - 1388-5021 (Print)
VI - 54
IP - 7
DP - 2000 Sep
TI - Benefits of a standardized feeding regimen during a clinical trial in preterm neonates
PG - 429-31

AB - The feeding regimen was standardized for a trial of erythromycin to reduce the time to reach full feeds (150 ml fed/day) by 20% in neonates of < or = 32 weeks gestation. No significant improvement was noted in the primary outcome (median time erythromycin 93.5 vs placebo 104 hours, P = 0.60). However, necrotizing enterocolitis > or = stage II disappeared and the time to full feeds was reduced by over 50% in all neonates during the 18-month trial and for more than two years after the trial when the standardized feeding regimen was adopted as routine policy for feeding neonates of < or = 32 weeks (< 28 weeks: 13 vs 4.8 days, P < 0.05; > 28 weeks: 8 vs 3.9 days, P < 0.05). This was in contrast to an average of six cases of NEC per year with 45% mortality during the previous five years. The benefits of standardized feeding schedules - improved detection and treatment of signs/symptoms of feed intolerance - are emphasized.
AD - Department of Neonatology, K. H. Hospital for Women, Queensland, Australia

Semantic Groups Legend

Disorders
Physiology
Procedures
Concepts & Ideas
Geographic Areas
Living Beings
Chemicals & Drugs

Notes:
1) Underscoring denotes Phrase Head
2) Denotes Phrase Boundary
Genre and Task Issues (1 of 2)

- **Term processing (-z)**
  - Input is terms (one per line), not complete sentences
- **Browse mode (-zogm)**
  - Used with Large Scale Vocabulary Text (LSVT)
  - Exhaustive search of the Metathesaurus
  - Voluminous output
  - Not appropriate for use with final mapping construction
Genre and Task Issues (2 of 2)

• Negation (--negex)
  • Important for clinical text
  • Based on Wendy Chapman’s NegEx algorithm
• Word Sense Disambiguation (-y)
  • Based on Susanne Humphrey’s Journal Descriptor Indexing
  • Provides modest improvement in results
Algorithm Tuning

- Variant suppression
  - Suppress variants of one- and two-character words
  - e.g., in *t-cell* suppressing variants of *t* prevents mapping to ‘TX’ and ‘TS’

- Efficiency modifications
  - Due to growth of Metathesaurus (440K – 2M concepts)
  - Caching results in AVL trees (self-balancing binary trees) rather than linear lists
  - Expanding caching scope from a phrase to a citation
  - Replacing findall/3 calls with recursive code
  - Significantly faster then before (at least 3-5 times)
Future MetaMap Development

• Further technical development
  • Migration from Sun/Solaris to Linux environment
  • Update to current Berkeley DB to prepare for
  • Migration from Quintus to SICStus Prolog
• Augment tokenization with chemical name recognition
• Enhance MetaMap’s WSD accuracy with additional WSD algorithms
• Further enhancement of processing short words, especially acronyms/abbreviations
Pointers


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