An iconic approach to the browsing of medical terminologies

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Introduction

Medical terminologies: the basis of interoperability in medicine
- But difficult for a Humans to find the right term in 10,000+ terms!

In pharmacovigilance, experts often perform searches in case database
- e.g. find all cases of “renal abscess” associated with drug X
- Adverse drug events are coded in MedDRA

Problems:
- Search must be exhaustive, but natural language is very precise
- Synonymy, polysemy, false friends: “tumor of cardia”
- It is also difficult to obtain an overview of a terminology

=> we developed since 11 years VCM, an iconic language for representing medical concepts
- Not as precise as text, but useful for enriching texts and facilitate searches
- Previously applied to drug knowledge, electronic health records, decision support systems

Objective: propose a iconic interface for browsing medical terminologies
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   ✦ e.g. find all cases of “renal abscess” associated with drug X
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Existing approaches for browsing and searching medical terminologies

- **Navigation in a hierarchy (tree)**
  - Long and tedious, user is rapidly lost in the tree
  - Not well-suited for multiaxial terminologies (including MedDRA)
  - Overview is limited to a single level
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Lexical search with keywords (e.g. “renal abscess”)
- Synonyms: “kidney abscess”
- Hyponyms/hypernyms: “abscess perinephric”
- Polysemy: “auricular” matches both heart and ear-related terms

Brown EG. Methods and pitfalls in searching drug safety databases utilising the Medical Dictionary for Regulatory Activities (MedDRA). Drug Saf 2003
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- **Post-coordination with compositional terminologies**
  - [Cornet, Lee, Souvignet]
    - “renal abscess” => renal + abscess
    - But it requires to enter complex queries
    - => “Visual post-coordination” with VCM
An iconic language for medical concepts [BMC]
- Symptoms
- Disorders
- Treatments
- Exams
- Adverse effects

Combinatorial grammar
- 150 pictograms
- 5 colors
- 30 shapes

=> thousands of icons

A formal semantics, based on an OWL 2.0 ontology [KBS]
VCM
(Visualization of Concepts in Medicine)

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**A formal semantics, based on an OWL 2.0 ontology [KBS]**
Methods: Model mapping MedDRA to VCM

**OWL ontology including:**
- ~70,000 MedDRA terms and ~2,400 VCM icons
- ~530,000 RDF triples (46 Mb)
- $\mathcal{ALILF}(D)$ description logics family

**MedDRA to VCM mapping [MIE 2018]**

**Designed with Owlready ontology-oriented programming module**
- Translate the ontology to an SQL database
- Support full-text search

---

**MedDRA term**

<table>
<thead>
<tr>
<th>level</th>
<th>code</th>
<th>label</th>
</tr>
</thead>
<tbody>
<tr>
<td>{SOC, HLGT, HLT, PT, LLT}</td>
<td>string</td>
<td>string</td>
</tr>
</tbody>
</table>

**Icon**

<table>
<thead>
<tr>
<th>has_part</th>
</tr>
</thead>
</table>

**Pictogram**

<table>
<thead>
<tr>
<th>has_icon</th>
</tr>
</thead>
</table>

**child_of / parent_of**

French Book available on Owlready!
Methods: Search strategies

- **Lexical search**
  - Search with one or more keywords
  - Auto-completion
  - Uses Owlready / SQLite3 implementation

Type one or more keywords then enter:
Methods: Search strategies

- **Lexical search**
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- **Iconic search**
  - Select one or more pictograms
  - From the 37 most generic pictograms in VCM
  - Organized on “Mister VCM”, an anatomical schema
  - If several pictograms are selected, their intersection is considered
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**Hierarchical search**
- Limited to the ability to filter by depth
- 5 depth levels in MedDRA
Methods: Search strategies

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- **Hierarchical search**
  - Limited to the ability to filter by depth
  - 5 depth levels in MedDRA

The 3 strategies can be used alone or in combination, in any order.
**Methods: Search algorithm**

```python
function lexico_icono_hierarchical_search(keywords, pictograms, selected_levels):
    if only keywords (i.e. pictograms = ∅):
        terms = { t such that MedDRA(t) and match(t.label, keyword) and t.levels ∈ selected_levels }  
        icons = { i such that Icon(i) and ∃ t ∈ terms with has_icon(t, i) }
    else if only pictograms (i.e. keywords = ∅):
        icons = { i such that Icon(i) and ∀ p ∈ pictograms we have has_part(i, p) }
        terms = { t such that MedDRA(t) and t.levels ∈ selected_levels and ∃ i ∈ icons with has_icon(t, i) }  
        icons = { i such that i ∈ icons and ∃ t ∈ terms with has_icon(t, i)}
    else (both keywords and pictograms):
        terms = { t such that MedDRA(t) and match(t.label, keyword) and t.levels ∈ selected_levels }  
        icons = { i such that Icon(i) and ∀ p ∈ pictograms we have has_part(i, p) }
        terms = { t such that t ∈ terms and ∃ i ∈ icons with has_icon(t, i) }
        icons = { i such that i ∈ icons and ∃ t ∈ terms with has_icon(t, i)}
    return (icons, terms)
```
Methods: Display of the search results

Search results are often numerous!

- Use VCM Icons to organize them

Icons associated with the retrieved MedDRA terms are displayed

- Icons are sorted by number of terms
- At most 5 terms are displayed per icons
  - Click on them to display the entire list
- Icons are grouped according to inheritance rules in VCM
  - e.g. Icon for “renal blood vessel occlusion” is grouped under icon for “renal circulation”

<table>
<thead>
<tr>
<th>Icon</th>
<th>Terms</th>
</tr>
</thead>
</table>
| ![icon](image1.png) | + Adult polyglucosan body disease (PT)  
+ Automatic bladder (PT)  
+ Bladder dilatation (PT)  
+ Bladder disorder (PT)  
+ Bladder diverticulum (PT)  
... (207 terms) |
| ![icon](image2.png) | + Accessory kidney (PT)  
+ Aminoaciduria (PT, 2 icons)  
+ Aplasia pure red cell (PT, 3 icons)  
+ Benign familial haematuria (PT, 2 icons)  
+ Berdon’s syndrome (PT, 2 icons)  
... (156 terms and 8 child icons) |
| ![icon](image3.png) | + Adenoviral haemorrhagic cystitis (PT)  
+ Aorta hypoplasia (PT, 2 icons)  
+ Atrophie blanche (PT, 3 icons)  
+ Bladder hyperaemia (PT)  
+ Bladder telangiectasia (PT)  
... (144 terms and 41 child icons) |
| ![icon](image4.png) | + Autoimmune nephritis (PT)  
+ Bladder granuloma (PT)  
+ Bladder irritation (PT)  
+ C3 glomerulopathy (PT)  
+ Chemical cystitis (PT)  
... (138 terms and 21 child icons) |
Results

⚠ Good performances

⚠ < 0,6 seconds (on a local server, online demo is slower)

⚠ Demo!

Example of a search combining keywords, icons and depth levels:

Type one or more keywords then enter:

abscess

Abscess
Abscess NOS
Abscess jaw
Abscess leg
Eye abscess
Abscess hand
Abscess limb
Abscess neck
Abscess oral

331 MedDRA terms found:

- Amoebic brain abscess (PT)
- Bacterial abscess central nervous system (PT)
- Brain abscess (PT)
- Central nervous system abscess (PT)
- Dural abscess (PT)
  ... (39 terms and 5 child icons)

- Bartholin's abscess (PT)
- Breast abscess (PT)
- Clitoris abscess (PT)
- Fallopian tube abscess (PT)
- Genital abscess (PT)
  ... (35 terms and 9 child icons)

- Abscess drainage (PT)
- Abscess management (PT)
- Abdominal wall abscess drainage (LLT)
- Abscess breast drainage (LLT)
- Abscess cavity curettage (LLT)
  ... (33 terms)

- Abscess oral (PT)
- Gingival abscess (PT)
- Nasal abscess (PT)
- Peritonsillar abscess (PT)
- Pharyngeal abscess (PT)
  ... (26 terms and 4 child icons)

- Perinephric abscess (PT)
- Renal abscess (PT)
- Urachal abscess (PT)
- Ureter abscess (PT)
- Urethral abscess (PT)
  ... (17 terms and 3 child icons)

- Abscess (PT)
- Abscess limb (PT)
- Abscess rupture (PT)
- Abscess soft tissue (PT)
- Abscess sterile (PT)
  ... (38 terms)

- Abscess sweat gland (PT)
- Periumbilical abscess (PT)
- Subcutaneous abscess (PT)
- Abscess apocrine gland (LLT)
- Abscess of external ear (LLT)
  ... (33 terms and 4 child icons)

- Abscess intestinal (PT, 2 icons)
- Anal abscess (PT)
- Appendiceal abscess (PT)
- Colonic abscess (PT)
- Douglas' abscess (PT, 3 icons)
  ... (27 terms and 3 child icons)

- Abdominal abscess (PT)
- Abdominal wall abscess (PT)
- Abscess intestinal (PT, 2 icons)
- Douglas' abscess (PT, 3 icons)
- Mesenteric abscess (PT, 2 icons)
  ... (20 terms)

- Biliary abscess (PT)
- Gallbladder abscess (PT)
- Hepatosplenic abscess (PT, 2 icons)
- Liver abscess (PT)
- Perihepatic abscess (PT, 3 icons)
  ... (13 terms and 3 child icons)
Example of a search combining keywords, icons and depth levels:

Type one or more keywords then enter: abscess

And/or click on icons:

Show levels: ☐ SOC
☐ HLGT
☐ HLT
☐ PT
☐ LLT

17 MedDRA terms found: +++
- Abscess kidney (LLT)
- Abscess perinephric (LLT)
- Peri-nephric abscess (LLT)
- Peri-nephric abscess NOS (LLT)
- Perinephric abscess (PT)
- Renal abscess (PT)
- Renal abscess NOS (LLT)
- Renal and perinephric abscess (LLT)
- Urachal abscess (PT)
- Urinary tract abscess (PT)
- Peri-urethral abscess (LLT)
- Peri-urethral abscess NOS (LLT)
- Skene's duct abscess (LLT)
- Urethral abscess (PT)
- Urinary bladder abscess (PT)
- Ureter abscess (PT)
- Ureter abscess NOS (LLT)
**Example of an iconic search on the eye:**

<table>
<thead>
<tr>
<th><strong>3650 MedDRA terms found:</strong></th>
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</tr>
</thead>
<tbody>
<tr>
<td>AIDS retinopathy (2 icons)</td>
<td>Abducent nerve operation</td>
<td>Acute haemorrhagic conjunctivitis (2 icons)</td>
</tr>
<tr>
<td>Abnormal sensation in eye</td>
<td>Acquired epiblepharon</td>
<td>Anterior chamber angle neovascularisation</td>
</tr>
<tr>
<td>Accommodation disorder</td>
<td>Acute haemorrhagic conjunctivitis (2 icons)</td>
<td>Anterior segment ischaemia</td>
</tr>
<tr>
<td>Acquired corneal dystrophy</td>
<td>Anomaly of orbit, congenital</td>
<td>Arteriosclerotic retinopathy</td>
</tr>
<tr>
<td>Acquired lenticous</td>
<td>... (767 terms and 25 child icons)</td>
<td>Choroidal effusion ... (312 terms and 15 child icons)</td>
</tr>
<tr>
<td>... (1059 terms)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abscess of eyelid</td>
<td>Blindness traumatic (2 icons)</td>
<td>Aniridia</td>
</tr>
<tr>
<td>Acanthamoeba keratitis</td>
<td>Bowman's membrane injury</td>
<td>Anomaly of orbit, congenital</td>
</tr>
<tr>
<td>Acute haemorrhagic conjunctivitis (2 icons)</td>
<td>Cataract operation complication</td>
<td>... (225 terms and 8 child icons)</td>
</tr>
<tr>
<td>Adenoviral conjunctivitis</td>
<td>Cataract traumatic</td>
<td></td>
</tr>
<tr>
<td>Bacterial blepharitis</td>
<td>Chorioretinal scar</td>
<td></td>
</tr>
<tr>
<td>... (293 terms and 23 child icons)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute myopia</td>
<td>Anterior chamber cell</td>
<td>Blood clot</td>
</tr>
<tr>
<td>Amaurosis</td>
<td>Anterior chamber fibrin</td>
<td>Bilateral myopia</td>
</tr>
<tr>
<td>Amaurosis fugax (2 icons)</td>
<td>Anterior chamber flare</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Amblyopia</td>
<td>Anterior chamber inflammation</td>
<td></td>
</tr>
<tr>
<td>Amblyopia alcohol (2 icons)</td>
<td>Aqueous fibrin</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>... (218 terms and 6 child icons)</td>
<td>... (206 terms and 11 child icons)</td>
<td></td>
</tr>
<tr>
<td>Benign neoplasm of choroid</td>
<td>Angiogram retina</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Benign neoplasm of conjunctiva</td>
<td>Angiogram retina abnormal</td>
<td></td>
</tr>
<tr>
<td>Benign neoplasm of cornea</td>
<td>Biopsy cornea</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Benign neoplasm of eye</td>
<td>Biopsy cornea abnormal</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Benign neoplasm of eyelid</td>
<td>Biopsy eyelid</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>... (150 terms and 19 child icons)</td>
<td>... (137 terms and 9 child icons)</td>
<td></td>
</tr>
<tr>
<td>Anterior capsule contraction</td>
<td>Anterior vitreous hemorrhage</td>
<td></td>
</tr>
<tr>
<td>Anterior chamber collapse</td>
<td>Autoimmune uveitis</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Capsular block syndrome</td>
<td>Birdshot chorioretinopathy</td>
<td></td>
</tr>
<tr>
<td>Cataract operation complication</td>
<td>Neumyestis optica spectrum disorder</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Ciliary zonular dehiscence</td>
<td>Ocular pemphigoid</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>... (65 terms and 11 child icons)</td>
<td>... (39 terms and 6 child icons)</td>
<td></td>
</tr>
<tr>
<td>Alport's syndrome (3 icons)</td>
<td>Eye pain</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Blau syndrome (3 icons)</td>
<td>Eyelid pain</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Carney complex (4 icons)</td>
<td>Aching eye socket</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Congenital optic nerve anomaly</td>
<td>Blepharal pain</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Cri du Chat syndrome (2 icons)</td>
<td>Dull eye pain</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>... (30 terms and 4 child icons)</td>
<td>... (28 terms)</td>
<td></td>
</tr>
<tr>
<td>Albinism</td>
<td>Dark circles under eyes</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Endocrine ophthalmopathy (2 icons)</td>
<td>Device optical issue</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Hypercarotinaemia</td>
<td>Glassy eyes</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Kayser-Fleischer ring (2 icons)</td>
<td>Immune recovery uveitis</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Lecithin-cholesterol acyltransferase deficiency (2 icons)</td>
<td>Subacute myelo-optic neuropathy (2 icons)</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>... (15 terms and 3 child icons)</td>
<td>... (8 terms and 2 child icons)</td>
<td></td>
</tr>
<tr>
<td>EPCOF examination</td>
<td>Chronic enlargement of lacrimal gland</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Lid parallel conjunctival folds examination</td>
<td>Corneal hypertrophy</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Slit-lamp examination</td>
<td>Lacrimal gland enlargement</td>
<td>Bilateral retinal detachment</td>
</tr>
<tr>
<td>Slit-lamp tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slit-lamp tests abnormal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glaucma drug therapy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example of an iconic search on the eye:

3650 MedDRA terms found:

- AIDS retinopathy (2 icons)
- Abnormal sensation in eye
- Accommodation disorder
- Acquired corneal dystrophy
- Acquired lenticonus
- ... (1059 terms)

- Abscess of eyelid
- Acanthamoeba keratitis
- Acute haemorrhagic conjunctivitis (2 icons)
- Adenoviral conjunctivitis
- Bacterial blepharitis
- ... (293 terms and 23 child icons)

- Acute myopia
- Amaurosis
- Amaurosis fugax (2 icons)
- Amblyopia
- Amblyopia alcohol (2 icons)
- ... (218 terms and 6 child icons)

- Benign neoplasm of choroid
- Benign neoplasm of conjunctiva
- Benign neoplasms of cornea

33 MedDRA terms found:

- Allergic keratitis
- Allergic keratoconjunctivitis
- Allergic rhinitis due to pollen (2 icons)
- Atopic cataract
- Atopic keratoconjunctivitis
- Birch pollen allergy (2 icons)
- Blepharitis allergic (2 icons)
- Contact and allergic dermatitis of eyelid (2 icons)

- Eye allergy
- Grass allergy (2 icons)
- Hay fever (2 icons)
- Pollen allergy (2 icons)
- Poliomyelitis (2 icons)
- Ragweed allergy (2 icons)
- Rhinitis seasonal (2 icons)
- Seasonal allergic rhinitis (2 icons)
- Seasonal allergy (2 icons)
- Seasonal conjunctivitis (2 icons)
- Seasonal nasopharyngitis (2 icons)

- Conjunctivitis allergic
- Giant papillary conjunctivitis
- Scleritis allergic
- Acute atopic conjunctivitis
- Allergic blepharoconjunctivitis
- ... (12 terms)

- Oculo-respiratory syndrome (3 icons)
- Oculorespiratory syndrome (3 icons)

- Acute haemorrhagic conjunctivitis (2 icons)
- Anterior chamber angle neovascularisation
- Anterior segment ischaemia
- Arteriosclerotic retinopathy
- Choroidal effusion
- ... (312 terms and 15 child icons)

- Albinism
- Alstroem syndrome (2 icons)
- Amblyopia congenital (2 icons)
- Aniridia
- Anomaly of orbit, congenital
- ... (225 terms and 8 child icons)

- Abducting nerve operation
- Amblyopia therapy
- Biopac eye surgery
- Blepharoplasty
- ... (170 terms and 9 child icons)

- Angle closure glaucoma
- Borderline glaucoma
- Developmental glaucoma
- Diabetic glaucoma (2 icons)
- Exfoliation glaucoma
- ... (79 terms)

- Allergic keratitis
- Atopic cataract
- Atopic keratoconjunctivitis
- Blepharitis allergic (2 icons)
- Conjunctivitis allergic
- ... (33 terms and 3 child icons)

- Acquired pigmented retinopathy
- Amblyopia alcohol (2 icons)
- Amblyopia tobacco
- Chemical burns of eye
- Chemical eye injury
- ... (23 terms and 4 child icons)

- Cataract associated with radiation and other physical influences
- Cataract radiation
- Radiation cataract
- Radiation corneal injury
- Radiation retinopathy
- ... (2 child icons)

- Acromegaly
- Acromegaly (2 icons)
- Acromegaly (3 icons)
- Acromegaly (4 icons)
- Acromegaly (5 icons)

- Mikulicz's disease (2 icons)
- Mikulicz's syndrome (2 icons)
Expert opinions

The interface was tested by 2 pharmacovigilance experts

- Very few pharmacovigilance experts => difficult to recruit

Purely iconic search: not so interesting...

Combined iconic and lexical search: very interesting for exhaustive searches

- Can increase the sensibility of the search, because VCM pictograms are broader than keywords

“VCM is an Esperanto of medical language”

Useful for students and non-experts such as clinical research associates (CRA)

- e.g. VCM icons explicitly represent “cardia” as related to the stomach

Tumor of cardia
Discussion

- An original approach for browsing and searching medical terminologies
  - A new application for the VCM iconic language
  - Facilitate exhaustive searches
  - Overview of the terminology

- Limitations
  - Requires to map the terminology with VCM
  - Requires to train users in VCM icons

- In the literature [Massari et al.]
  - Meta-terms based on medical specialties for facilitating searches
  - But textual and not iconic
Conclusion

➡️ Icons are a new and promising approach for browsing and searching medical terminologies

➡️ Perspectives

🔗 Evaluation of the interface in a pharmacovigilance setting
🔗 Adaptation to other terminologies
  - e.g. for coding electronic health records (EHR): ICD10, SNOMED CT
🔗 Use in medical education
References


[AIM]: Lamy JB. Owlready: Ontology-oriented programming in Python with automatic classification and high level constructs for biomedical ontologies. Artif Intell Med 2017;80:11-28