Decision Support for the LHS: The LHS Needs a “Brain”

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September 25, 2015
Creating a “Brain” for a Learning Health System

- I could learn if only I had a brain

The Health Care System stands tall, makes a difference, and yet is propped up and unresponsive, as is a scarecrow
So What’s in a Complete Platform?

Mechanisms for managing communities of interest

- Technology and policy for making knowledge persistent and sharable
- Technology for aggregating and analyzing data
- Policies governing access to data
- Mechanisms for tailoring messages to decision makers
- Mechanisms for capturing changed practice
- Decide to Study
- A Problem of Interest
- Interpret Results
- Collect Data
- Take Action to Change Practice
- Deliver Tailored Message
- Analyze Data
- Assemble Data
The LHS Needs a *Brain* to Drive the Efferent Side

LHS components to organize, manage and provide access to what is learned, i.e., to knowledge.

At scale, the Brain is a Digital Library of Learning. There can be one such library, or many.

A Brain Contains Knowledge

Examples of knowledge are...

<table>
<thead>
<tr>
<th>Regression Equation*</th>
<th>Clinical Calculation*</th>
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<tbody>
<tr>
<td>Checklist</td>
<td>Template</td>
</tr>
<tr>
<td>Guideline</td>
<td>Predictive Model</td>
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<tr>
<td>Decision Model</td>
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</tbody>
</table>

* The demo in this presentation uses these two types of knowledge – the demo is of a clinical risk calculation based on a regression equation.
## Specific Functions of a Brain

<table>
<thead>
<tr>
<th>Basic Brain Functions</th>
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</thead>
<tbody>
<tr>
<td>Organize knowledge to know what is known</td>
</tr>
<tr>
<td>Manage knowledge to know <em>about</em> what is known</td>
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<tr>
<td>Represent and provide knowledge for use</td>
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</table>

<table>
<thead>
<tr>
<th>Advanced Brain Functions</th>
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</thead>
<tbody>
<tr>
<td>Formulate tailored advice</td>
</tr>
<tr>
<td>Infer what is <em>not yet</em> known</td>
</tr>
<tr>
<td>Predict an individual’s immediate knowledge needs</td>
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Creating a “Brain” for an LHS

Precursor A
Create Digital Knowledge Repositories

Precursor B
Make Digital Knowledge as Explicit and Transactional as Possible

Step 1
Wrap Pieces of Digital Knowledge in Descriptive Metadata

Step 2
Associate Pieces of Digital Knowledge with Terminologies & Ontologies

Step 3
Interrelate Pieces of Digital Knowledge in a Knowledge Network

Organize knowledge to know what is known
Manage knowledge to know about what is known
Represent and provide knowledge for use
Formulate Tailored Advice
Infer what is NOT YET known
Predict Knowledge Needs
Use the Fedora Commons Digital Knowledge Repository

• An open source management system for digital content
• Scalable knowledge engineering and management system
• Ready solution that speeds up LHS “brain” development
• Proven system already in use by libraries worldwide

No need to start from scratch.

https://wiki.duraspace.org/display/FF/Fedora+Repository+Home
The Brain is Composed of Digital Knowledge Objects

Digital Knowledge Object (DKO)

Fedora is for storing and managing DKO.

Step 1
Wrap Pieces of Digital Knowledge in Descriptive Metadata

Metadata wrapper
DKO Metadata Types Can Be Many

Step 1
Wrap Pieces of Digital Knowledge in Descriptive Metadata

- Who, What, Why, When
- Version
- Security, Authorization, Authentication
- Domains, Ranges, Scope of Application

knowledge payload

DKO
Example Prostate Cancer Risk DKO

University of Michigan, Prostate Cancer Risk Model, Predict Risk Prior to Biopsy, November 3, 2015

\[
y = -1.8 \times 0.8(\log(PSA)) \times 0.2(\text{FamHistory}) \times -0.4(\text{PriorBiopsy})
\]

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Cancer, Prostate Cancer, Men 55 years and older

SNOmed-CT: PSA(102687007)
ICD-9 CM: NEOPLASM OF UNCERTAIN BEHAVIOR OF PROSTATE(236.5)

Step 2
Associate Pieces of Digital Knowledge with Terminologies & Ontologies
DKOs can be Explicitly Linked

Step 3
Interrelate Pieces of Digital Knowledge in a Knowledge Network

DKO networks afford new capabilities.
### Analogous Functions and Capabilities

<table>
<thead>
<tr>
<th>Necessary “Brain” Function</th>
<th>Knowledge Repository Capability</th>
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</thead>
<tbody>
<tr>
<td>Know what is known</td>
<td>Semantically-aware information retrieval</td>
</tr>
<tr>
<td>Know what is NOT YET known</td>
<td>Inference-making to identify knowledge gaps automatically</td>
</tr>
<tr>
<td>Manage what is known</td>
<td>Digital library for versioning, governance, &amp; curation</td>
</tr>
<tr>
<td>Represent knowledge for use</td>
<td>Transactional, coded, computable knowledge via APIs</td>
</tr>
<tr>
<td>Formulate advice</td>
<td>Quick development &amp; rapid deployment of advice-giving systems</td>
</tr>
<tr>
<td>Predict immediate knowledge needs</td>
<td>Relate “pieces” of knowledge to each other in a knowledge network</td>
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</table>
We’re Building the Brain (Collaborators Welcome!)

- We have developed a prototype design based on the Fedora Commons platform
- An open “brain service” usable at many levels of scale
- We have assembled a technical team
- We are applying for funding to create a mature version, but expect to have a working, open source prototype in 6-8 months
- For technical details: