The New Era of High Functionality Computing

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Computers are too damn complicated.
Three big issues

Complexity

Can’t keep growing interfaces simply by adding new functions

Instructibility

How do we tell computers what we want them to do?

Risk

What happens if something goes wrong?
AI in user interfaces

Goal-oriented interfaces
End-user programming
End-user debugging
Intelligent defaults
Recommender systems
High Functionality (hi-fun) computing

Computer can perform a large number of independent operations

Each operation might be complex (perform non-trivial transformation, have many steps)

Operations may interact

Many data types

May have to learn abstract concepts

Much potential for human error
Low-functionality (lo-fun)

Only a small number of operations
What each operation does is “obvious”
Small number of intuitive data types
Little potential for human error
Hi-fun vs. lo-fun (image editing)
Hi-fun vs. lo-fun (phones)

Phone marketed to seniors

Android phone
We need a new synthesis of AI and HCI for hi-fun interfaces

AI stuck on “Turing Test” complete AI
AI stuck on math+algorithms
HCI paralyzed by fear of AI failures
HCI stuck on designing for low-functionality interfaces.
Not on a sustainable path for interface innovation

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Complexity

Can we manage complexity with “good design” according to “user-centered” principles?

“Simplify” interfaces – small number of operations
Organize logically – “affordances”
Reflective software

| SELF-IDEALS | Concerned with relationship between this mind and others, including self-appraisal by comparing one's abilities and goals with those of others. |
| SELF-CONSCIOUS | Concerned with relationship between this mind and others, including self-appraisal by comparing one's abilities and goals with those of others. |
| SELF-REFLECTIVE | Concerned with larger scale models of 'self', including the extent and boundaries of one's physical and cognitive abilities and knowledge. |
| REFLECTIVE | Reflects on and manages deliberative activity, including assigning credit to inference methods, selecting suitable representations, and so forth. |
| DELIBERATIVE | Reasons about the situations and events in the external world, e.g. prediction, explanation, planning, diagnosis, generalization. |
| REACTIVE | Reflexes and scripted, automatic responses to opportunities and emergencies that occur in the external world. |

**Figure 1. Causal-diversity matrix**

- **Numbers of Causes**: Few (Easy) to Many (Connectionist Neural Network Fuzzy Logic)
- **Scale of Effect**: Small (Ordinary Qualitative Reasoning) to Large (Case-based Reasoning)
- **Using magnitudes helps make comparisons by hiding**
- **Find better representation!**

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Good design helps, but...

Conventional HCI design is based on a *one-to-one* correspondence between controls and functions. But as functions grow, controls can’t keep up. Each “app” might be simple, but what happens when you have hundreds, thousands of them? Apps grow over time as features are added. How do they work together?
How do we get out of the dilemma?

Goal-Oriented Interfaces

People have goals

"I want to record some music on my piano and put it on my Web page"

Devices (or software) have functions

Record a MIDI file, play it through a synth, audio to MP3, upload to server, edit page

Whose job is it to map between goals and functions?
Roadie

Natural language and commonsense knowledge for goal recognition

Partial-order planning for goal satisfaction

Help, debugging tools when things go wrong
Roadie

- listen the radio
- watch television
- listen to a music CD
- None of the above

Show EventNet output

Steps involved:
1. Connect the cable of speaker and radio
2. Turn on the radio
3. Turn on the speaker
4. Select the input of speaker that connects to radio
5. Select the output of radio that connects to speaker

What do you like to do?
I would like to hear the news

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Siri, Google Now

First commercial appearance of goal-oriented interfaces
What’s next?

Integrate with broad spectrum of applications
Integrate speech and visual interface
Multiple step and parameterized procedures
Programming by example and automation
Personalization
Critique and dialogue
Hypothesis: Common sense reasoning is the key to making usable/helpful applications.

Minority viewpoint: Minsky, Lenat...

So, let’s collect Commonsense and figure out how to:

- Reason with it
- Integrate it into interfaces
Open Mind Commons

Explain your world.

Knowledge about fruit

Similar objects to fruit: food, apple, cookie, vegetable, potato

Fruit is referred to with these phrases: fruit, a fruit, Fruit, fruits, Fruits, some fruit, some fruits, Some fruit, an fruit, A fruit

An inquiring mind wants to know...

Is this generally true?
You are likely to find a fruit in a kitchen.
Yes / No / Doesn't make sense / Why do you ask?

Is this generally true?
You are likely to find a fruit in a restaurant.
Yes / No / Doesn't make sense / Why do you ask?

Is this generally true?
You are likely to find a fruit in a table.
Yes / No / Doesn't make sense / Why do you ask?

Current knowledge

- An apple is a kind of fruit.
  - Score: 39
  - Rate...

- Orange is a type of fruit.
  - Score: 31
  - Generally true

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ConceptNet - Liu, Singh, Eslick
AnalogySpace – Speer, Havasi, Kuo
Applications in Interface Agents

Predictive typing, Speech recognition
Storytelling with Media Libraries
Detection and mitigation of online bullying
Opinion Analysis
Goal-oriented interfaces for Consumer Electronics
Mobile to-do lists, location-aware context-sensitive maps
Translation, language learning & multi-lingual communication
Help and customer service
Recommendation systems, scenario-based recommendation
Programming and code sharing in natural language
... and more
Applications in Interface Agents
Cyberbullying

Problem of Cyberbullying
Affects 43% of kids
2011 White House Conference on Cyberbullying
NLP for identifying possible cyberbullying topics
Fathom - Dinakar

Assistant for helping online counselors
If you have a large or open-ended command set, how do you make it easily usable?

- Natural Language interfaces / Speech reco
- End-User Programming
  Programming by Example
- Dynamic / Adaptable command sets
- Self-teaching interfaces, personalization
Books

- Your Wish Is My Command
- End User Development

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Programming in Natural Language

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Computers need to instruct humans in hi-fun interfaces

Programming is the human instructing the computer

But the computer also needs to instruct the human

Collaborative problem solving around shared goals

The world seems to have given up on help systems ?!
How do you learn a hi-fun interface?

… or any complex topic?

Learn by example, a little bit at a time…

Experience success quickly on a simple, but nontrivial example

Learn essential concepts that will enable you to learn more over time
Dimensions in learning

*Autonomy:* You do it / I do it?

*Context:* In-context / out of context?

*Risk:* Works / Doesn’t work?

*Style:* Top-down / Bottom-up?
The “Paradox of Help”

You can be shown how to do something
But then you don’t get the feeling of DIY
You can try by yourself
But then you might get lost or stuck
But why should you be forced to make these choices in advance?

Suppose we

• Give you a variety of choices?
• Let you choose at each step?
• Change your mind if you get it wrong?
Steptorials (Stepper tutorial)
Hi—fun interfaces involve more risk, because there are more wrong paths than right paths.

Reduce risk by giving the user the ability to deal with problems as they arise.

Remove fear of trying new technology.
End-User Debugging

Like program debugging, except the user can’t see the program!

Gotta (re-)construct the program based on user interaction

Provide reversible stepper
Conclusion

We’re entering an era of high-functionality computing

That’s a good thing!

AI is crucial for dealing with major issues:

  Complexity
  Instructibility
  Risk
Commonsense as key

Hypothesis: Common sense reasoning is the key to making usable/helpful applications

Minority viewpoint: Minsky, Lenat...

So, let’s collect Commonsense and figure out how to

• Reason with it

• Integrate it into interfaces
But does it “make sense” to work on Common Sense?

How much Commonsense is in a person’s head?

Isn’t Commonsense knowledge hopelessly vague, ambiguous, context-dependent?

Isn’t it different for different people, cultures?

What if it makes a mistake in the interface?
Good news: It’s feasible

A person lives for 3 billion seconds
CSK much less, maybe 10s to 100s millions
Storing / search that much stuff OK today
Will show you many CSK applications to convince you of utility
Big Data / Machine Learning

Hot topic – where we are in Moore’s Law

Learning from observation / learning from knowledge

What’s correlated / What’s interesting/important

Complementary techniques, hijack math for aggregation

Some signs coming together, e.g. “deep learning”
Welcome to Open Mind Common Sense!

Computers don't currently know the basic things about the world that we consider "common sense." Here, you can help build a database of such knowledge in simple English sentences. The computer will analyze these sentences to connect concepts and draw new conclusions from the things you teach it.

Getting started

If you want to interact with OpenMind and teach it new things, log in to get started!

Languages

Open Mind is collecting knowledge in multiple languages:

- English: 1032498 statements
- Traditional Chinese: 356277 statements
- Portuguese: 233440 statements
- Korean: 14952 statements
- Japanese: 14546 statements
- Dutch: 6065 statements
- Hungarian: 2154 statements
- French: 204 statements
- Spanish: 157 statements
- Italian: 98 statements
Open Mind Common Sense

“Crowdsourced” Common Sense
Direct typein, games, mining
12 years, 20K users
1 Million English statements, + other languages
CN5 on order of 10 million + web resources
Open Mind Commons - Speer

Knowledge about fruit

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fruit is referred to with these phrases: fruit, a fruit, Fruit, fruits, Fruits, some fruit, some fruits, Some fruit, an fruit, A fruit

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Current knowledge

→ An apple is a kind of fruit.
  by kynn
  Score: 39
  Rate...

→ orange is a type of fruit.
  by jaegnum
  Score: 31
  Generally true
  Rate

Recently learned

- taking final exams is for passing a class.
  (by rseper)
- dish could be broken.
  (by rseper)
- You would study because you have a test.
  (by rseper)
- You would take final exams because you are being tested.
  (by havasi)
- the beach is wet.
  (by havasi)
- Cookies are sugary.
  (by rseper)
- apricots are a kind of fruit.
  (by rseper)
- a laptop is a kind of portable computer.
  (by rseper)
- a laptop is a kind of computer.
  (by rseper)
- A lake is wet.
  (by rseper)
# Effect of the parser

<table>
<thead>
<tr>
<th>What the contributor says</th>
<th>What OpenMind hears</th>
</tr>
</thead>
<tbody>
<tr>
<td>A goldfish is a type of carp that makes a nice pet</td>
<td>A goldfish is a carp</td>
</tr>
<tr>
<td>A nightgown is a long, loose garment worn to bed</td>
<td>A nightgown is a garment</td>
</tr>
<tr>
<td>A uniform is a special outfit worn by members of a group</td>
<td>A uniform is a outfit</td>
</tr>
<tr>
<td>A foot is a unit of measurement equal to twelve inches</td>
<td>A foot is a unit of measurement</td>
</tr>
<tr>
<td>A hut is a small, simple shelter</td>
<td>A hut is a shelter</td>
</tr>
</tbody>
</table>
## ConceptNet relations

<table>
<thead>
<tr>
<th>Label</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>IsA</td>
<td>Hockey is a sport.</td>
</tr>
<tr>
<td>PartOf</td>
<td>A finger is part of a hand.</td>
</tr>
<tr>
<td>AtLocation</td>
<td>You are likely to find a book in a library.</td>
</tr>
<tr>
<td>MadeOf</td>
<td>Windows are made of glass.</td>
</tr>
<tr>
<td>UsedFor</td>
<td>Pens are used for writing.</td>
</tr>
<tr>
<td>CapableOf</td>
<td>Boats can float on water.</td>
</tr>
<tr>
<td>HasProperty</td>
<td>Sunsets are beautiful.</td>
</tr>
<tr>
<td>Desires</td>
<td>A person wants love.</td>
</tr>
<tr>
<td>CausesDesire</td>
<td>Being cold would make you want to light a fire.</td>
</tr>
<tr>
<td>Causes</td>
<td>The effect of having a haircut is to have shorter hair.</td>
</tr>
<tr>
<td>MotivatedByGoal</td>
<td>You would do housework because you want to have a clean house.</td>
</tr>
<tr>
<td>HasSubevent</td>
<td>One of the things you do when you read a book is turn pages.</td>
</tr>
<tr>
<td>HasFirstSubevent</td>
<td>The first thing you do when you go for a drive is get in the car.</td>
</tr>
<tr>
<td>HasLastSubevent</td>
<td>The last thing you do when you take a shower is dry off.</td>
</tr>
<tr>
<td>HasPrerequisite</td>
<td>If you want to get fit, you should lift weights.</td>
</tr>
<tr>
<td>DefinedAs</td>
<td>Death is the end of life.</td>
</tr>
<tr>
<td>ReceivesAction</td>
<td>An apple can be eaten.</td>
</tr>
<tr>
<td>ObstructedBy</td>
<td><em>(Quando se tenta dormir, um problema encontrado pode ser insônia.)</em></td>
</tr>
<tr>
<td>CreatedBy</td>
<td>Music is created by composing.</td>
</tr>
</tbody>
</table>
ConceptNet - Liu, Singh, Eslick
AnalogySpace – Speer, Havasi
What AnalogySpace can do

It can generalize from sparsely-collected knowledge

It can identify the most important dimensions in a knowledge space

It can classify concepts along those dimensions

It can create ad-hoc categories (and classify accordingly)

It can confirm or question existing knowledge
# AnalogySpace matrix

<table>
<thead>
<tr>
<th>Features / Concepts</th>
<th>Ice</th>
<th>Book</th>
<th>Magazine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used-For Cooling</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Has-Part Pages</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Used-For Reading</td>
<td>No</td>
<td>Yes</td>
<td>?</td>
</tr>
</tbody>
</table>
## AnalogySpace matrix

<table>
<thead>
<tr>
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<th>Ice</th>
<th>Book</th>
<th>Magazine</th>
</tr>
</thead>
<tbody>
<tr>
<td>? Used-For Cooling</td>
<td>1</td>
<td>-0.93</td>
<td>-0.879</td>
</tr>
<tr>
<td>? Has-Part Pages</td>
<td>-1</td>
<td>0.88</td>
<td>0.925</td>
</tr>
<tr>
<td>? Used-For Reading</td>
<td>-1</td>
<td>0.987</td>
<td>?</td>
</tr>
</tbody>
</table>
Dimensionality Reduction

Height and Weight of 8 Subjects

Weight (pounds)

Height (inches)
Singular Value Decomposition

\[
\begin{bmatrix}
\text{features} \\
A
\end{bmatrix}
\approx
\begin{bmatrix}
\text{concepts} \\
U_k
\end{bmatrix}
\begin{bmatrix}
k \text{ axes} \\
\Sigma_k
\end{bmatrix}
\begin{bmatrix}
k \text{ axes} \\
V_k^T
\end{bmatrix}
\begin{bmatrix}
\text{features} \\
k \text{ axes}
\end{bmatrix}
\]
Traditional Logical Inference

Inferences goes from

True assertion $\rightarrow$ True assertion
via Inference Rules

Good news: Very precise and reliable

Bad news: Proof search blows up exponentially

Requires precise definitions and assertions

GIGO
AnalogySpace Inference

All possible assertions put in a (big, sparse) box

You can rearrange the box along semantic axes

Good news: Computationally efficient

Tolerant of imprecision, contradiction, disagreement…

Stronger than statistical inference

Bad news: Can’t be guaranteed to be very precise
Not-so-Common Sense

Use Common Sense tools & methodology, but knowledge only common to a small group

Collect knowledge from natural language sources

Collect knowledge from games

Collect knowledge from existing DBs, Ontologies, ..

"Blend" with general Commonsense knowledge

→ AnalogySpace for specific domain
Blending - Havasi

Inference combining two AnalogySpaces

Specialized and generalized knowledge bases

Blending factor
AI in user interfaces

Intelligent defaults
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Applications in Interface Agents

Predictive typing, Speech recognition
Storytelling with Media Libraries
Detection and mitigation of online bullying
Opinion Analysis
Goal-oriented interfaces for Consumer Electronics
Mobile to-do lists, location-aware context-sensitive maps
Translation, language learning & multi-lingual communication
Help and customer service
Recommendation systems, scenario-based recommendation
Programming and code sharing in natural language
... and more
Related Work

Cyc

Thought Treasure

Logic, Axiomatization of Commonsense Domains

Semantic Web / Linked Data

Freebase, other curated collections

Nell, machine learning mining Web
Let’s beat some Common Sense into computers!
Marvin Minsky, 1926-2016
“To see how minds are like societies, try this: pick up a cup of tea!

Your GRASPING agents want to keep hold of the cup. Your BALANCING agents want to keep the tea from spilling out… Yet none of these consume your mind. You scarcely think at all about Balance; Balance has no concern with Grasp; Why not? If each does its own little job, the really big job will get done by all of them: drinking tea.”
Reflective software

**SELF-IDEALS**
Concerned with relationship between this mind and others, including self-appraisal by comparing one's abilities and goals with those of others.

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Reflexes and scripted, automatic responses to opportunities and emergencies that occur in the external world.

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**Figure 1. Causal-diversity matrix**

Using magnitudes helps make comparisons by hiding

Find better representation!