A Clinical View of Requirements Engineering

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A Team Effort!

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Talk Outline

- Working definition of a clinical process illustrated with Eye Clinic.
- Second example using rehabilitation field (extends the process).
- Description of four-year study using email as treatment (uses the process).
- Current status and future work.
- Conclusion.
The Clinical Process: a Working Definition

- Starts With a Human-Centric Problem Domain

Flow Chart:
- Initial Exam
- Treatment Package
- Adapt
- Monitor
- Check-Ups
Sub-processes of Initial Exam

- Individual Assessment
- Requirements Acquisition

Activities of daily living (ADLs) affecting vision
The Treatment Cycle

Initial Exam → Specification → Adapt → Monitor

Check-Ups
Key Points of Clinical Process

- **Individual process:** assumes (a) one-size-fits-all solution will fail, and (b) problem changes over time in individualized ways.

- Assessment implies a skills inventory. For optometry, a theory of vision under varying circumstances.

- Treatments imply a solution-theory that maps assessed skills (e.g., unaided eyesight), combined with requirements, to solutions.

- Process assumes that both humans and their environment can change over time. Hence, treatment comes in two sides of same coin: (a) what is delivered initially, and (b) what new/adapted solutions are delivered by monitoring over time.
Another Clinical Process: Rehabilitation

 Starts With a Human-Centric Problem Domain

Initial Exam
  Deferred Goals
  Treatment Package

Monitor
  Adapt

Check-Ups
Introduction of Goal-Attainment Scale

- self-care skills (dressing, eating, bathing, going to the bathroom)
- home-care skills (cooking, cleaning)
- work and leisure skills (using a phone, transportation)
The Modified Treatment Cycle

- Initial Exam
- Specification
- Adaptation is driven by attainment levels.
- Adapt
- Monitor
Key Points of Extended Process

- Goal-Attainment Scale (GAS) implies a decomposition of the domain into measurable sub-goals or levels of attainment.

- People are encouraged to set long-range goals. Goals/levels that are not immediately applicable are deferred.

- Deferred goals have some metric that allows them to be monitored for applicability.

- Monitoring is goal-based. The goals of an individual are used to prune the entire monitoring space.
Can Software Play a Role in Treatment?

- Staying in the Rehabilitation field, I will switch to Cognitive Rehabilitation.
- Within this field, I will focus on survivors of a Traumatic Brain Injury (TBI). Numbers are roughly 6-10 million in US.
- The Cognitive Rehabilitation field is not a software domain, per se. However, it follows a clinical process that includes a GAS component.
- The challenge handed to me was to work-in a software component to a treatment package, and working backwards, into the entire clinical process.
Two general classes of problems:

1. Memory
   - Short term memory (holding on to set)
   - Anterograde memory (memory for new learning)

2. Executive functions
   - Initiation
   - Organization
   - Planning
   - Self-monitoring
   - Inhibition

*Impairment space* is taken by expanding each issue on a severity scale, and then taking the cross-product of all issues + severity.

It is difficult to identify the typical brain-injured individual from...
A Social-Reconnection Clinic for TBI Survivors

- Clinic staff includes academics and practitioners from the fields of Cognitive Rehabilitation, Training/Education, Qualitative Studies, Field Observation, Computer Science.

Working with clinic staff, I came up with two potential treatments: (1) email as a way to reconnect with friends and family (and to make new friends), and (2) navigation aids to support trips that provide reconnection with the physical community.

In spring of 2001 we embarked on the email project.

Diagram:
- Initial Exam
  - Deferred Goals
  - Treatment Package
    - Adapt
    - Monitor
  - Check-Ups
A Social-Reconnection Clinic for TBI Survivors

We started here

Initial Exam → Treatment Package

Deferred Goals

Adapt → Check-Ups

Monitor
The Email Client

- In the summer of 2001, we ran a pilot study to determine the range of email clients (and features) that made sense for the clinic audience.

- We determined that COTS email clients were not a solution.

- We also noted the variability we saw in different individuals.

- This led to our construction of a configurable email client.

- Closed buddy list.
- Fixed windows.
- Minimize access to OS interface.
- Control of process different individuals.
- Control of composition.

Chat window:

- Date: April 24 (Sat)
- Yes and no. Steve decided that I was being unfair, so he told everyone. It was one of the posters you brought from TR.
- On Fri Apr 23 15:20:24 GMT-08:00 2004 Laurie wrote: Hi Jim,
- Did we EVER correctly guess what the green thing was in the TAL lab?
- Type your email to Jim, then click send
- Unfair about what? I don't get it :)

Options:
- Shut Down
- Send
- Cancel
1. The social space: configuration of the buddy list.

2. The email-process space: user-control vs. system-control.

3. The composition space: freeform vs. guided.

Roughly $10 \times 10 \times 10 \times 10$ configurations.
A Social-Reconnection Clinic for TBI Survivors

We next looked here

- Initial Exam
- Deferred Goals
- Treatment Package
- Adapt
- Monitor
- Check-Ups
# A Skills-Study of Emailing

<table>
<thead>
<tr>
<th>Initial Exam</th>
<th>Letter keys, Special characters, Arrow keys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Assessment</td>
<td>Mouse movement, Clicking</td>
</tr>
<tr>
<td>Goal Attainment Scale</td>
<td>Interface navigation</td>
</tr>
</tbody>
</table>

- Six month project produced roughly 50 skills
**Email GAS**

**General Goal Patterns**
- Reconnect with friends and family
- Learn something new
- Advocate (e.g., congressman, SIG)

**Idiosyncratic Goals**
- Work on getting inheritance cleared up
- Distribute poetry
A Social-Reconnection Clinic for TBI Survivors

Note: assistive-technology (AT) abandonment is well-known for this population. Saw this play out in our clinic in terms of the treatment cycle.
Weekly Evaluation

Deferred goal becomes active goal.

Configuration changes
Case Study: Yolanda

- Yolanda is a 37-year old, Native American female with cognitive disabilities due to a traumatic brain injury from a motor vehicle accident 17 years prior to the study.

- She demonstrated severely impaired anterograde memory (mild) and executive functions (e.g., initiation, organization, planning, self-monitoring, inhibition) in addition to a left visual field-cut.

- She is single and lives in a minimal-care supported-living community. Staff assist Yolanda in her medication management, personal finances, and in networking with the local community support groups and counselors.

- She is independent using the bus to visit familiar locations around town.

**Yolanda’s Impairments**

<table>
<thead>
<tr>
<th>1. Memory</th>
<th>2. Executive functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term memory</td>
<td>Initiation</td>
</tr>
<tr>
<td>Anterograde memory</td>
<td>Organization</td>
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<td></td>
<td>Planning</td>
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<td></td>
<td>Self-monitoring</td>
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<tr>
<td></td>
<td>Inhibition</td>
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<tr>
<td>(moderate)</td>
<td>(mild)</td>
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<tr>
<td>(mild)</td>
<td>(moderate)</td>
</tr>
<tr>
<td></td>
<td>(severe)</td>
</tr>
<tr>
<td></td>
<td>(severe)</td>
</tr>
</tbody>
</table>
One of Yolanda's Goals

Goal: contribute to an online newsletter

**Level 1**: can do simple email correspondence.

**Level 2**: will be able to write letter-style email (size, topic).

**Level 3**: will have one letter printed in the newsletter.

**Level 4**: will have regular letters printed in the newsletter.

**Level 5** (fully attained): will be asked to write a guest letter.
### Yolanda's Timeline of Adaptation

<table>
<thead>
<tr>
<th>Time</th>
<th>Adaptation within composition space:</th>
<th>Adaptation within process space:</th>
<th>Adaptation within social space:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Change to: freeform composition</td>
<td></td>
<td>Change to: added editor to buddy list</td>
</tr>
<tr>
<td>3-6</td>
<td>Linked-goal: letter-style content</td>
<td></td>
<td>Linked-goal: submit to newsletter</td>
</tr>
<tr>
<td>6-9</td>
<td>Triggered-by: meeting size constraints</td>
<td></td>
<td>Triggered-by: consistent performance</td>
</tr>
<tr>
<td>9-12</td>
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<td>12-15</td>
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<td>15-18</td>
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<tr>
<td>18-21</td>
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</tbody>
</table>

**Initial system:**
- Controlled composition (size limit)
- Restricted process (reply required)
- Short buddy list (two relatives)
Adaptation management is a critical problem:

1. **Missed adaptations.**
   
   A modification was needed and either (a) monitoring did not pick it up or (b) staff evaluation of monitored data did not pick it up.

2. **Superfluous adaptations.**
   
   Typically, project staff inferred the need for an adaptation that was either (a) not supported by monitoring data, or (b) did not match with a user’s goals.

Example of the former: ADLs that are hard to monitor, e.g., changing meds.

Examples of the latter: lots 😞. But it got better as we built up higher level concepts from raw monitoring data. And were better able to know individual behavior patterns.

Example of the former: attempts to use time as a measure, e.g., after 6 months, most should be ready for a less-intrusive system.

Examples of the latter: our good, but misguided intentions, e.g., changes to social space when not goal-directed.
Summary to Date

- Ten participants in study: 4 have been emailing a year or longer, 4 have been emailing at least 6 months, and 2 have just entered the study.

- They range in living environments: 3 live in their own homes, 4 live in a minimal-care facility, and 3 live in a full-care facility.

- All reported an inability to use a computer when entering the study.

- None were able to use a COTS email client during the initial exam. Same result at 6-month re-exams: none have been able to use COTS email without FTF staff support.

- The good news: all participants continue to use email successfully. All have reached at least minimal attainment of their goals.
Current and Future Work

Adding 2nd treatment package

Use of Formal Modeling in Adaptable Systems

Pondering a mainstream clinic, e.g., Digital Imaging Clinic.

Scale and automation issues

Applications

Infrastructure
Scale Issues, One By One

Initial Exam

Monitor

Adapt

Deferred Goals

Check-Ups

Hardening our configurable client

Labor-intensive process now. Some automation is needed.
Two Important Scale Questions

1. Can we automate portions of the monitor-adapt cycle? 
   [and by backchaining] 

2. Can we formalize the assessment and goal-attainment processes?
A First Cut at Formalizing GAS

The KAOS Tool as a Means to Formalize GAS

1. A means to refine a goal into levels.
   Yes. Rich language of goal refinement.

2. A means of attaching skill prerequisites to goals.
   We are extending the language to include this.

3. A means of linking prerequisites to performance.
   We are extending the language to include this.

4. A means of reasoning about events in past, present and future.
   Yes. Use of LTL-style logic to reason temporally.
ReqMon: Linking KAOS Goals to Monitoring (credit to Bill Robinson)

A means of attaching skill prerequisites to goals.

A means of reasoning about events in past, present and future.

A means of linking goal activation to performance.

(GOAL ReplyInTimelyFashion
(BaseSkills: ReadSkill ReplySkill ...)
(MonitoredSkills: ThesholdReadAndReply ...)
...

(MONITOR ThesholdReadAndReply
(Count: read: event
  (m1:EmailMessage, u1,u2:User
   EmailRead(m1,u2,u1))
(Count: reply: event
  (m1:EmailMessage, u1,u2:User
   (EmailRead(m1,u2,u1) ->
    <> EmailReply(m1,u1,u2))))
(Trigger: (reply/read > .75) over 14d)
...
A Small Case Study: Ron’s Buddy List

Data Mining

- **Test:** rational-reconstruction of adaptations seen on project.
- **Goal monitored:** Ron wanted to eventually have lots of buddies.
- **Data collected:** Ron’s daily activity in correspondence.
- **Adaptation looking for:** add new buddy to Ron’s list.
Results
✓ Placed monitored data in Excel.
✓ Plotted using various curve fitting and running average techniques.
✓ Potential correlation between down-trend in activity and adding buddy.

Future
➢ Use ReqMon data-miner to analyze, rather than Excel
➢ Use regression, neural net, & statistical correlation techniques

Read/reply within a session.
Number of different buddies sent to in a session.
Total number of sends in a session (could be all to same buddy).
**Reasoning About Adaptation**

**Ties to adaptive systems in HCI.**

*Related to look-and-feel adaptations (see GITK).*

**Ties to adaptive business-rules.**

*Just starting to look here.*

**Ties to the social-space of email.**

*Growing body of work on MoSoSos.*
Conclusions I Feel Safe Making

- Clinical fields take a personal view of treatment, and often employ the GAS approach to structure treatment.
- Cognitive Rehabilitation Clinics are a logical place to start to provide computer-based tools to a marginalized population.
- It is possible to work a Personal RE process into these clinics and have success in tool delivery and sustainability.
- Scale issues are challenging (but interesting 😊).
Sponsors Acknowledgement

- Intel
- National Institute on Disability and Rehabilitation Research
- Shelter Care
- TriMet
- National Science Foundation
- Lane Transit District
Web Sites

http://www.go-outside.org

http://www.think-and-link.org
Talk Bibliography


- Sohlberg, McKay Moore; Ehlhardt, Laurie A; Fickas, Stephen; Sutcliffe, Alistair. A pilot study exploring electronic (or e-mail) mail in users with acquired cognitive-linguistic impairments. *Brain Injury*. Vol 17(7) Jul 2003, 609-629


- Fickas, S. Clinical Requirements Engineering. Invited paper at the *27th International Conference on Software Engineering* (Extending the Discipline track), St. Louis, May 2005


Thank You