Uncertainty Modeling for Threat Analysis

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• Purpose of paper
  – Create basic understanding to enable...
    • A framework for situation- and threat analysis
    • Situation awareness solutions for C2-systems, in particular decision-aids
    • Machine intelligence enhancements
    • Powerful, organized, and guided operations
    • Individual action
  – Prevent misapplication of socio-technical systems

• Concepts: Fundamental (maybe trivial, maybe imprecise in English language)
• Generic terms (concerning staff member, soldiers, but also others...)

• We do NOT...
  – Provide guidelines or solutions
  – Present experimental results
  – Solve specific operative problems
  – Elaborate on threats
Cognitive perspective

Inside world matters more
- Acting on “the moment”
- Holistic, Adaptive
- State-based, timeless
- Adjusting mind to world
- Reflection/intuition
- Central: Creativity!
- “We live in the best of all possible worlds”
  — Leibniz

Outside world matters more
- Acting on specified information
- Databased, Systemic, Complex
- Logical timeline
- Adjusting world to mind
- Formalised procedures
- Central: C2-system!
- “We must cultivate our garden”
  — Voltaire
Information perspective

Cognition

Perception

Information arena

Physical arena
The problem: Situation management

- What must we know in order to act?
- What does the situation picture mean?
- What is a threat? Where? When?
- How do we prevent/prepare/respond?
Decision support

**KNOWLEDGE**
- Ex. Maps provide background information
  - Nature and climate geography
  - Human and political geography
  - Minefields

**SITUATION AWARENESS (SA)**
- Ex. Drone provides situation imagery
  - Refugees traveling in a convoy
  - Time, location, speed

**PLANNING, DECIDING, ACTING**
- Based on KNOWLEDGE and SA
  - Time refugees will reach village?
  - Need of blankets, food, water?
  - Intersecting adversary groups?
  - Crossing of mine-fields?
Knowledge, Learning, Models

• "Know-how" models
  Principles, techniques, heuristics, etc
  – Expertise ↔ Acquiring experience
  – Ability ↔ Training/doing

• "Know-what" models
  Informs, guides perception, empirical
  – Understanding ↔ Analyzing
  – Facts ↔ Memorizing
## Self-awareness

- Central to decision quality
  - Optimal: Knowing our ability
- Limits courses of action, based on what we...
  - ...think we don’t or do know
  - ...think we can’t or can do

<table>
<thead>
<tr>
<th></th>
<th>Knowledge acquired</th>
<th>Knowledge gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aware</td>
<td>What we know we can do</td>
<td>What we know we can not do</td>
</tr>
<tr>
<td>Unaware</td>
<td>What we don’t know that we can do</td>
<td>What we don’t know that we can not do</td>
</tr>
</tbody>
</table>

- Central to enable our full potential
- Manifested in our requests for information (RFI)

Knowledge of own system → Quality of questions → Quality of info requested → Quality of decisions
Expectations & Negative Information

- Expectations among people are due to multiple sources:
  - Prejudice, World knowledge, self-awareness, Normality, Rules & Schemas, Task, Role, Situation development

- Expectations are coupled with situation reactions, such as:
  - Evaluation
    - Better or worse?
  - Surprise
    - Something we never seen before...
  - Consequences and complexity
    - Demand on reasoned response...

- Negative information: Something actively searched for and expected due to...
  - Relevance
  - Earlier measurements
  - Experience
  ...but not found when looking

- Opposed to Positive Information...
  ...but not same as lack of information!
Situation Awareness

• "The perception of the **elements** in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future”
  
  – Endsley

• **Elements** correspond to data representations in a knowledge system
Objective uncertainty in situation picture

- The elements are associated with objective uncertainties (from statistics)

- In all Kosovo: Probability of ethnicity:
  - P(Serb) = 0.07
  - P(Albanian) = 0.93

- On this road: Probability of destination
  - P(Mitrovica) = 0.8
  - P(Pristina) = 0.2
Subjective uncertainty in situation picture

- The *registration of elements* are associated with *technical* uncertainties

- The *perception of the elements* are associated with "*human factors*" uncertainties

"I just saw something strange on the sensor picture. I’m 90% sure it is troops."

"No, Sgt Expert said it is refugees, and he is always right about images."

"About supermodels he is..."
Uncertainty in decisionmaking

• Observe-Orient-Decide-Act (OODA-loop) in different time frames
• Uncertainties about situation picture
  – Diagnosis
  – Prognosis

• Uncertainties in Planning & Acting
  • Appropriate goal to achieve
  • Whether decision leads to goal fulfillment
  • Own abilities (performance, organization, loyalty)
Indicators

• Signs of something that has happened, is happening, will happen
• Different from verified facts: Contains uncertainty
• Can be combined during the exploration of an event or process

• Pierce: Indicators are *indexical signs* (in contrast to iconic or symbolic signs)
  – Temporally linked pattern elements (e.g., pre-quake seismic motions)
  – Direct effects (e.g., submarine engine sound)
  – Manifestations (e.g., expression of emotions)
  – Traces (e.g., a window left open)

• Indicators can be registered as an indication of...
  – Positive information (expected and found)
  – Negative information (expected but not found)

• Uncertainty of an indicator can be represented mathematically with a probability

• Indicators can be linked to each other in networks
Impactorium

- Based on a formalized situation description model, with: events, states, indicators, situations, etc

- Visualize events and the likelihood that they will occur.

- Sort and filter reports, depending on criteria that the user sets

- Visualize activation of events within an impact matrix

- Links reports to a map
Insecurity

• A sub-optimal mental or physical state, often manifested by danger, pain, or disability.
  – Caused externally (violence, threat)
  – Caused internally (deficiency or inbalance)

• "Osäkerhet" (Swedish) or "Unsicherheit" (German) can mean...
  – Insecurity
  – Uncertainty
  – Shakiness
  – Unsureness
Uncertainty * Insecurity in Decisionmaking

- Decisionmaking under stress (or in danger)
  - Uncertainty about situation picture caused by mental distortion (fear, fatigue, suppression, etc)
  - Diagnosis problem

- Uncertainty about a danger in situation picture
  - Risk = Uncertainty * Security
    - General: Probability * Consequence in risk mgmt.
    - Uncertainty about object existence
    - Uncertainty about dangerous nature
  - Prognosis problem

- Combination: *Diagnosis and prognosis* under stress
  - Ex. Analyzing a potential IED
  - Ex. Calling in air support/artillery on moving targets under on-going red-blue force battle
Can we act...? Do we want to act...?

<table>
<thead>
<tr>
<th>Inability</th>
<th>Unwillingness</th>
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<tbody>
<tr>
<td><strong>Caused from environment</strong></td>
<td><strong>Caused in individual</strong></td>
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<tr>
<td>- High demands, stress</td>
<td>- Lacking qualities or focus</td>
</tr>
<tr>
<td>- Chaos, Attack, Dangers</td>
<td>- Low endurance, performance</td>
</tr>
<tr>
<td>- Unfamiliar dynamic situation</td>
<td>- Injuries</td>
</tr>
<tr>
<td></td>
<td>- Expected regrets</td>
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<tr>
<td></td>
<td>- Belief in lacking qualities, low</td>
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<tr>
<td></td>
<td>performance, endurance</td>
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Freedom of Action

Ability & Will

Cognitive arena

Certainty
Information arena

Security
Physical arena

Action
perform, report, decide
Freedom of Action

Information arena:
- Trust in source
- Completeness
- Lack of information
  - Uncertainty

Cognitive arena:
- Experience
- Knowledge
  - Ability & Will
  - Expectations

Physical arena:
- Task and role
- Skills
- Threats
- Dangers
  - Security

Freedom of Action

Information needs
Presentation needs
Learning needs
Reports Decisions Actions
Application of technology

<table>
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<tr>
<th>Right</th>
<th>Wrong</th>
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</table>
| ![Right Image 1](image1.png)  
- Regarding knowledge-gap | ![Wrong Image 1](image2.png)  
- Disregarding security |
| ![Right Image 2](image3.png)  
- Regarding uncertainty | ![Wrong Image 2](image4.png)  
- Disregarding disability |
Questions?

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Thank you!