Information Foraging Theory for Control Room Resilience

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Overview

- What is Information Foraging?
- Information Foraging in Main Control Rooms
- Outstanding Research Issues

What is Information Foraging?

Foraging in Animals and Humans

The search for food

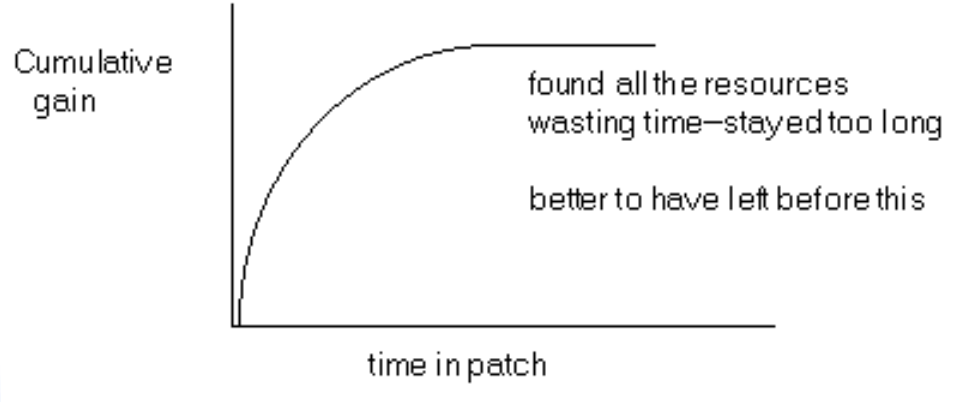
- Foraging theory = study of how animals and humans optimally look for food
  - Subfield of behavioral ecology
- Predicts that search for food in organisms is guided by highest fitness payoff
  - Highest food yield
  - Lowest cost of acquiring food
- Behavioral foraging strategies adapted to maximize this ratio
- Possible to model and predict foraging strategies

Foraging in Animals and Humans

A simple example

- Imagine an animal finding a patch of berries

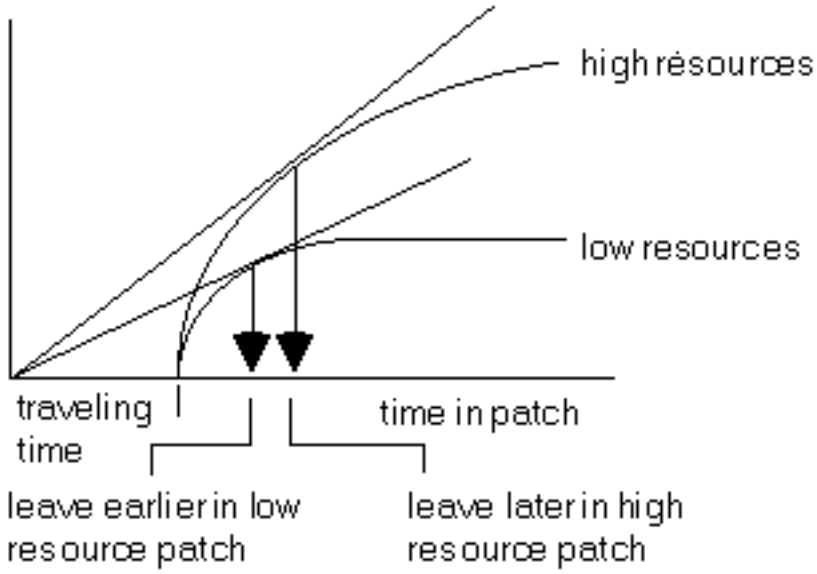
- Point of diminishing returns in terms of energy gained
- There is a time to abandon the patch



Foraging in Animals and Humans

A simple example (continued)

- The animal adapts its strategy to different types of berry patches



Foraging in Animals and Humans

Optimal foraging theory

- Optimal diet model
  - Describes the behavior of a forager that encounters different types of prey and must choose which to attack
- Patch selection theory
  - Describes the behavior of a forager whose prey is concentrated in small areas with a significant travel time between them
- Central place foraging theory
  - Describes the behavior of a forager that must return to a particular place in order to consume its food, or perhaps to hoard it or feed it to a mate or offspring.

A Different Type of Foraging

Assume that not everything of value is food

- Humans are **informavores** who seek and value information
- Humans develop different information seeking strategies depending on the quality of information
  - Some information has a low signal-to-noise ratio
    - E.g., an unproductive search term in an Internet search engine: `BAD NEIGHBORHOOD BOISE`
  - Some information has a high signal-to-noise ratio
    - E.g., a productive search term in an Internet search engine: `GOOD PIZZA BOISE`

Definition

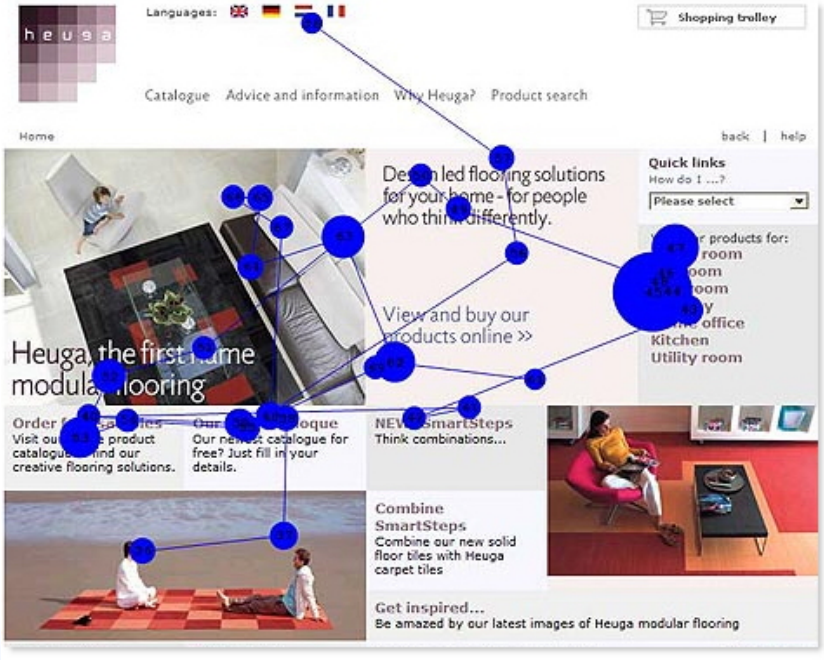
Information Foraging Theory

- Activities associated with seeking, acquiring, and handling information sources
- Adaptive process with regard to optimal use of knowledge about expected information value, expected cost of acquiring relevant information
- Based on optimal foraging theory, but adapted to how humans interact with information sources
  - Making sense out of ill-defined domain, e.g., finding the needle in the Internet haystack
- Seminal work by Peter Pirolli and Stuart Card at Xerox PARC on Web surfing

Simple Example

Information foraging within a simple Web page

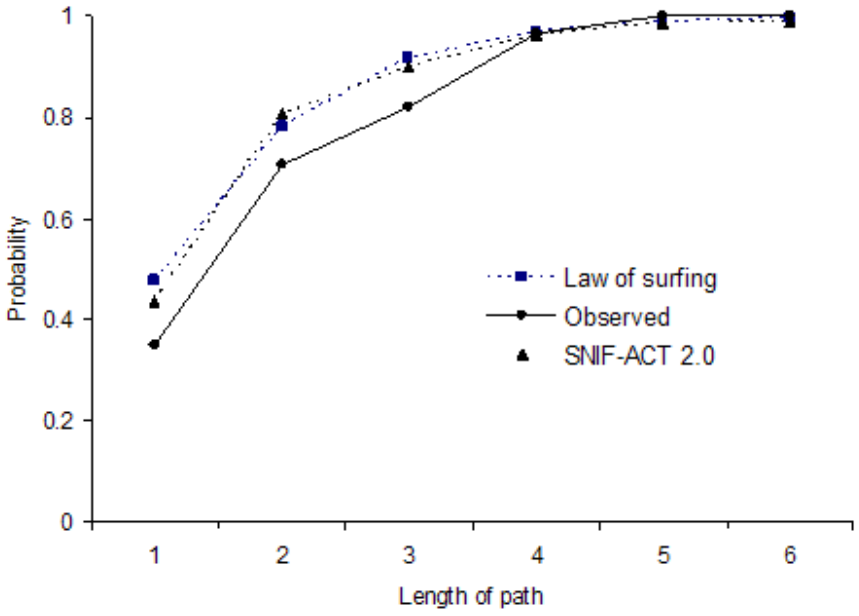
- Eyetracking shows how we forage around a page
  - Spend longer time on fruitful patches of information



Simple Example

Information foraging across Web pages

- We go through many pages looking for information
- Probability of finding right information increases as more pages visited
- Point of diminishing returns
- Likelihood of staying on a particular search path varies as a function of the quality of the information scent
  - This is a fruitful path vs. this is not a fruitful path



We are Wolves / We are Spiders

A wolf is a hunter

- Goes looking for its prey
- Information analogy: We seek information
  - We **pull** information to us

A spider builds a nest

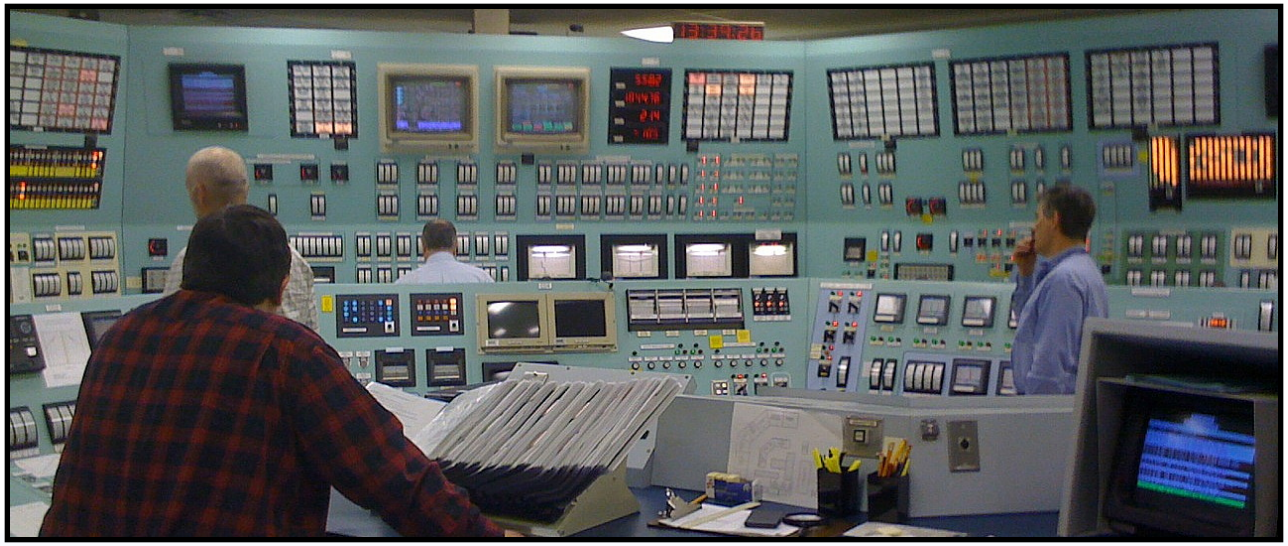
- Builds a Web and waits for its prey to come to it
- Information analogy: We subscribe to information that is relevant to us
  - Information is **pushed** to us

Information Foraging in Main Control Rooms

Information in Control Rooms?

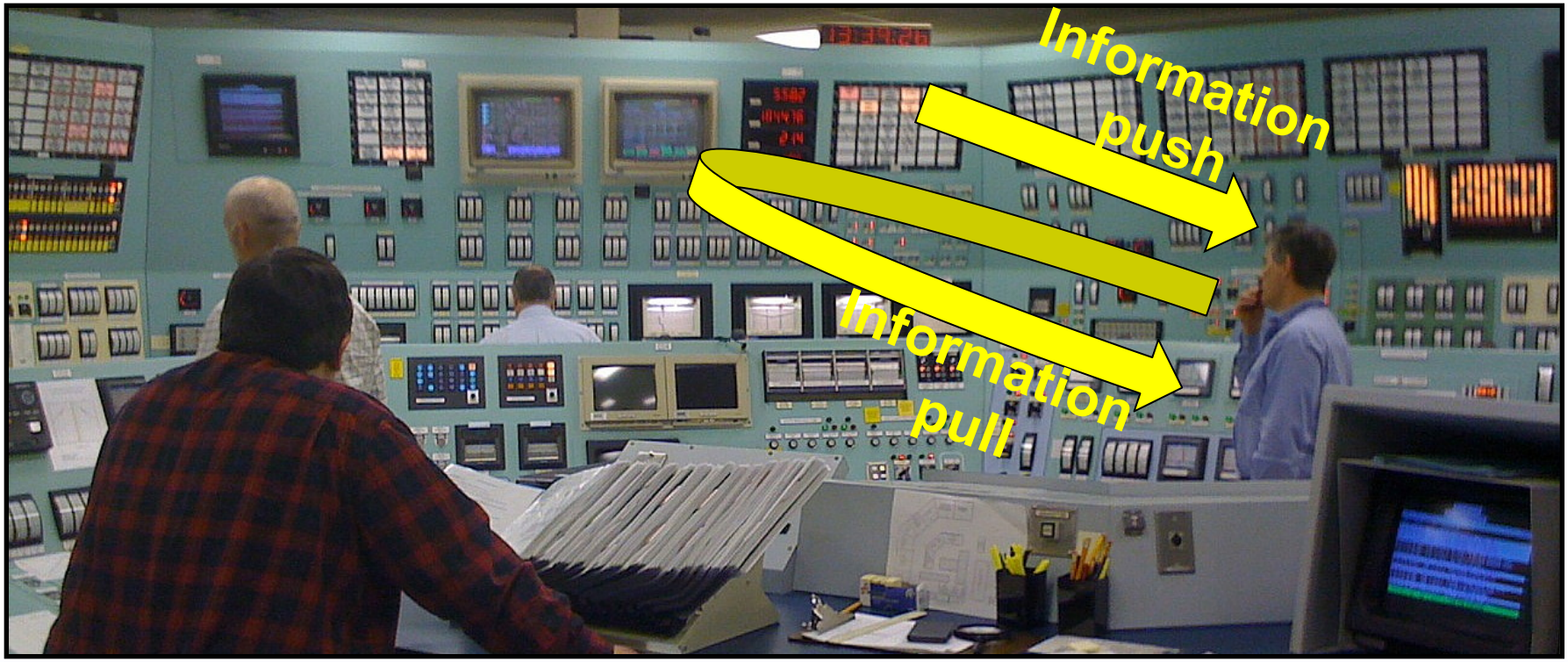
Current Control Rooms

- Status indicators and trend displays
- Alarms
- Procedures



Information in Control Rooms?

Are operators wolves or spiders?



Information in Control Rooms?

Are operators wolves or spiders? (continued)

- Wolves

Information in Control Rooms?

Are operators wolves or spiders? (continued)

- This process is not static

- Procedures may guide operator to change from spider to wolf or vice versa

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Information in Control Rooms?

Is information foraging a useful paradigm in control rooms?

- Is a model adapted from animal behavior to Web surfing explanatory of behaviors in control rooms?
  - Example: Information masking
    - Plant provides specific indicators of plant status, but indicators may be absent or misleading
      - How does this affect operator performance?
        - Operators are on the wrong information scent
        - Operators, who are efficient at foraging, may ignore information that is not perceived to have a fruitful yield for their hypothesized plant state

Information in Control Rooms?

Is information foraging a useful paradigm in control rooms?

- Is a model adapted from animal behavior to Web surfing explanatory of behaviors in control rooms? (continued)
  - Example: Display layout
    - Operators follow optimal foraging strategies in searching for information
    - They look for the shortest path with the most yield
    - Failing to provide indicators along a relevant foraging path may result in consistently overlooking or ignoring those indicators
    - No different than good layout, but it offers a theoretical basis

Information in Control Rooms?

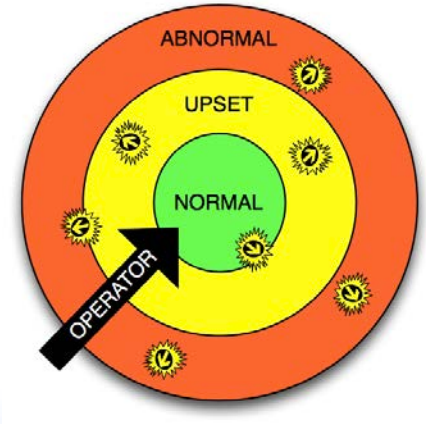
Is information foraging a useful paradigm in control rooms?

- Is a model adapted from animal behavior to Web surfing explanatory of behaviors in control rooms? (continued)
  - Example: Automated Plant Functions
    - Operators switch strategies between wolf and spider
    - This dynamic keeps operators engaged in plant and helps them forming active hypotheses about plant states and maintaining situation awareness
    - Automated plant functions result in lost engagement
    - Most plant automation systems keep operators as spiders
      - Is this a possible cause of lost engagement?

Information in Control Rooms?

Is information foraging a useful paradigm in control rooms?

- Is a model adapted from animal behavior to Web surfing explanatory of behaviors in control rooms? (continued)
  - Example: Alarm Response
    - Operators are overwhelmed by alarm floods and nuisance alarms in control rooms
    - Each alarm sends the operator on a path, but nuisance alarms drive the operator down the wrong information path
    - The problem is not information overload; it's information scent overload



Outstanding Research Issues

Information Foraging is Relevant

Information foraging already provides theoretical insights

- Well documented control room human factors issues seem to be covered by the general information foraging framework
- The explanations are plausible
- Reviewing work on information foraging as used in design and usability work in consumer software and Web interfaces suggests information foraging can help optimize
  - Display of information
  - Engagement of the user
- These issues have not been tested in a nuclear context

Some Research Questions

- Does information foraging account for documented normal and abnormal operations in nuclear power plant control rooms?
  - Mapping of information foraging model to operations experience
- Does information foraging help us improve our control rooms?
  - Is the model generative, and can it help us design better new systems?
  - Does information foraging tell us anything about how to present information?
  - Does information foraging identify performance weaknesses in our current control rooms?
- Is information foraging informative to resilience?

Questions?

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