King Saud University

College of Engineering

IE – 341: “Human Factors”

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Chapter 3. Information Input and Processing
Part – I*

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Chapter Overview

- Information:
  - How it can be measured (part I)
  - How it can be displayed (part II)
  - How it can be coded (part II)

Information Theory

- Information Processing is AKA:
  - Cognitive Psychology
  - Cognitive Engineering
  - Engineering Psychology
- Objectives of Information Theory:
  - Finding an operational definition of information
  - Finding a method for measuring information
  - Note, most concepts of Info. Theory are descriptive (i.e. **qualitative** vs. **quantitative**)
- Information (Def^{n}):
  - "Reduction of Uncertainty"
  - Emphasis is on "highly unlikely" events
  - Example (information in car):
    - "Fasten seat belt": likely event ⇒ not imp. in Info. Th.
    - "Temperature warning": unlikely event ⇒ imp.

Unit of Measure of Information

- Case 1: ≥ **1 equally likely alternative events**:

$$H = \log_2 N = \frac{\log N}{\log 2}$$

  - *H* : amount of information **[Bits]**
  - *N*: number of equally likely alternatives
  - e.g.: 2 equally likely alternatives ⇒ $H = \log_2 2 = 1$
    ⇒ **Bit** (Def^{n}): "amount of info. to decide between **two** equally likely (i.e. 50%–50%) alternatives"
  - e.g.: 4 equally likely alternatives ⇒ $H = \log_2 4 = 2$
  - e.g.: equally likely digits (0–9) ⇒ $H = \log_2 10 = 3.32$
  - e.g.: equally likely letters (a–z) ⇒ $H = \log_2 26 = 4.70$

Note, for each of above, unit [bit] must be stated.

Cont. Unit of Measure of Information

- Case 2: ≥ **1 non-equally likely alternatives**:

$$h_i = \log_2 \frac{1}{p_i}$$

  - h_i: amount of information [Bits] for single event, i
  - p_i: probability of occurrence of single event, i
  - Note, this is not usually significant

    (i.e. for individual event basis)

Cont. Unit of Measure of Information

- Case 3: **Average info. of non-equally likely series of events**:

$$H_{av} = \sum_{i=1}^{N} p_i \left(\log_2 \frac{1}{p_i}\right)$$

  - H_{av}: average information [Bits] from all events
  - p_i: probability of occurrence of single event, i
  - N: num. of non-equally likely alternatives/events
  - e.g.: 2 alternatives ($N = 2$)
    - Enemy attacks by land, $p_1 = 0.9$
    - Enemy attacks by sea, $p_2 = 0.1$
    - ⇒

$$H_{av} = \sum_{i=1}^{2} p_i \left(\log_2 \frac{1}{p_i}\right) = p_1 \left(\log_2 \frac{1}{p_1}\right) + p_2 \left(\log_2 \frac{1}{p_2}\right)$$

$$= 0.9 \left(\log_2 \frac{1}{0.9}\right) + 0.1 \left(\log_2 \frac{1}{0.1}\right) = 0.47$$

Cont. Unit of Measure of Information

- Case 4: **Redundancy**:
  - If 2 occurrences: equally likely ⇒
    - $p_1 = p_2 = 0.5$ (i.e. 50 % each)
    - $\Rightarrow H = H_{max} = 1$
  - In e.g. in last slide, departure from max. info.
    - = 1 – 0.47 = 0.53 = 53%
  - $$\% \, Redundancy = \left(1 - \frac{H_{av}}{H_{max}}\right) * 100$$
  - Note, as departure from equal prob. ↑ ⇒ %Red. ↑
  - e.g.: not all English letters equally likely: “th”,“qu”
    - ⇒ %Red. of English language = 68 %
    - PS. How about Arabic language?

Choice Reaction Time Experiments

- Experiments:
  - Subjects: exposed to different **stimuli**
  - **Response** time is measured
  - e.g. 4 lights – 4 buttons
- *Hick* (1952):
  - Varied number of stimuli (eq. likely alternatives)
  - He found:
    - As # of eq. likely alt. ↑ ⇒ reaction time to stimulus ↑
    - Reaction time vs. Stimulus (in Bits): **linear function**
- *Hyman* (1953):
  - Kept number of stimuli (alternatives) fixed
  - Varied prob. of occurrence of events ⇒ info. Varies
  - He found: **"Hick-Hyman Law"**
    - AGAIN: Reaction time vs. Stimulus (in Bits): linear function!