ELE 491
Senior Design Project Proposal

These slides are loosely based on the book Design for Electrical and Computer Engineers by Ford and Coulston. I have used the sources referenced in the book freely and without re-attribution. Please see the book for full source attribution

ELE 491
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Class 3 – Decision Systems

Decision Systems

Introduction

- Why do we need decision systems?
  - It is very rare that the solution to a problem is obvious
    - So rare – that if you think it is, you should move forward very cautiously
  - There are often competing requirements that need to be considered
    - Cost vs. Performance
    - Quality vs. Cost
    - Schedule vs. Quality
  - Decision systems provide an ordered process to weigh the competing requirements and choose a solution

Decision Systems

Introduction

- Informal Decision Systems
  - What's for dinner?
    - Mac-n-cheese and a hotdog
      - Cheap
      - Easy
      - 5 min in the microwave
      - Unhealthy
    - Chicken kabobs and a salad
      - More expensive
      - Difficult
      - 45 mins
      - healthy
  - Weekday or weekend?
  - Test tomorrow?
  - Just me?
  - Do I have the ingredients or do I need to get them?
  - Do I have any cash?
  - What have I had earlier in the week?

Decision Systems

Introduction

- Formal Decision Systems
  - Helpful at the personal level when making important decisions
    - College
    - Car
    - Home
  - Necessary in the business world
    - Always someone to justify your decisions to
      - Boss
      - Sr. Management
      - Stock holders
    - Impacts profits
    - Impacts strategy
    - Impacts jobs

Decision Systems

Introduction

- Formal Decision Systems
  - Many different approaches
    - Vary by company
    - Vary by project
    - Vary by team
  - Most have very similar attributes
    - Selection criteria
    - Criteria weightings
    - Possible solutions
    - Rating based on criteria
    - Scoring
    - Review
  - Vary by level of detail

Decision Systems

AHP

- Analytical Hierarchy Process (AHP)
  - Method used in the text
  - Similar to most methods

		Solution 1	Solution 2		Solution n
Criteria 1	ω_1	α_{11}	α_{12}	…	α_{1n}
Criteria 2	ω_2	α_{21}	α_{22}	…	α_{2n}
. . .	. . .	. . .	. . .	. . .	. . .
Criteria m	ω_m	α_{m1}	α_{m2}	…	α_{mn}
Score		$S_1 = \sum_{i-1}^{m} \omega_i \alpha_{i1}$	$S_2 = \sum_{i-1}^{m} \omega_i \alpha_{i2}$	…	$S_n = \sum_{i-1}^{m} \omega_i \alpha_{in}$

Decision Systems

AHP

- Criteria
  - What are the “things” you will look at to make your decision
  - These come from:
    - Marketing requirements*
    - Standards requirements
    - Performance specifications
    - Strategic considerations
    - Manufacturing requirements
    - Quality requirements
    - Intangibles

EX. Cell Phone Design

Nov 1, production ramp
LTE, UMTS, GSM
24hr battery life w/given profile
Special Verizon features
< 3 operator required tasks
Survive 4 ft. drop
“cool” color

* Many of the other criteria stem from marketing requirements

Decision Systems

AHP

- Criteria Weighting
  - Pairwise Comparison
    - Each criteria is compared against each of the others
    - Scale: relative importance of criteria
      - MORE: 1=equal, 3=moderate, 5=strong, 7=very strong, 9=extreme
      - LESS: 1/3=moderate, 1/5=strong, 1/7=very strong, 1/9=extreme
    - The geometric mean for each criteria is calculated to reduce rating inconsistencies
    - The means for all criteria are normalized to a sum of 1 → individual weights

Decision Systems

AHP

- Criteria Weighting
  - Book example – selection of a car
  - Criteria:
    - Purchase cost, Safety, Design, Brand
      - Cost is moderately more important than Design
      - Brand Name is extremely less important than safety

	Purchase Cost	Safety	Design	Brand Name
Purchase Cost	1	1	3	7
Safety	1	1	5	9
Design	1/3	1/5	1	3
Brand Name	1/7	1/9	1/3	1

Decision Systems

AHP

- Criteria Weighting
  - Book example – selection of a car
  - Quick Check
    - Diagonals should be anti-symmetric
  - Consistency
    - Purchase cost and Safety are equal – but
      - Purchase cost is moderately more important than Design
      - Safety is strongly more important than Design → inconsistencies

	Purchase Cost	Safety	Design	Brand Name	Geometric Mean	Weight ω_i
Purchase Cost	1	1	3	7	2.1	0.38
Safety	1	1	5	9	2.6	0.46
Design	1/3	1/5	1	3	0.7	0.12
Brand Name	1/7	1/9	1/3	1	0.3	0.05

Decision Systems

AHP

- Solution Rating
  - A rating mechanism is needed for each criteria
    - Cost → $
    - Design → Subjective
    - Safety → NHTSA ratings
    - Brand Name → J.D. Powers Brand Ranking
  - Ratings are normalized
    - Sum of all ratings for each criteria is normalized to 1
    - Care must be taken to ensure proper emphasis
      - If bigger is better – normalize the rating
      - If smaller is better – normalize 1/rating
    - This ensures the ratings do not bias the weightings previously calculated

Decision Systems

AHP

- Solution Rating
  - Cost

	Honda CRV	Hyundai Tucson	Toyota RAV4
Cost	$21,026	$18,183	$21,989
Cost α	0.32	0.37	0.31

  - Safety

NHTSA Rating	Honda CRV	Hyundai Tucson	Toyota RAV4
Rating	4.8	4.8	4.6
Safety α	0.34	0.34	0.32

Decision Systems

AHP

- Solution Rating
  - Design

DESIGN	Honda CRV	Hyundai Tucson	Toyota RAV4	Geometric Mean	Design α
Honda CRV	1	1/3	1/5	0.41	0.11
Hyundai Tucson	3	1	1/2	1.14	0.31
Toyota RAV4	5	2	1	2.15	0.58

  - Brand

JD Powers*	Honda CRV	Hyundai Tucson	Toyota RAV4
Rating	8.8	2.4	8.8
Brand α	0.44	0.12	0.44

* fictitious data

Decision Systems

AHP

- Scoring
  - Build out the AHP table with calculated weightings and ratings

Car Selection Matrix	Weight	Honda CRV	Hyundai Tucson	Toyota RAV4
Cost	0.37	0.32	0.37	0.31
Safety	0.46	0.34	0.34	0.32
Design	0.12	0.11	0.31	0.58
Brand	0.05	0.44	0.12	0.44
Score		0.31	0.34	0.35

Decision Systems

AHP

- Review
  - What do the final ratings mean
  - What is the margin or error
  - What is significant
  - If no clear winner – either
    - Review criteria and add additional measures
    - Provide alternatives to next level decision makers

Decision Systems

AHP

- Hierarchical Decision Processes
  - Additional levels of analysis within the given set of criteria
    - e.g. Cost → purchase + operating + insurance, …
  - Addition levels of decision
    - e.g. Car, # doors, convertible, engine selection, trim level
    - e.g. Processor type, # cores, chip supplier, memory

In Class Activity