- Utility function:- Assigns a single no. to express the desirabity of a state. Denoted as $U(s)$ for state s.
  + maps state to real nos.
- States give complete snapshots of world. similar to situations.
- Nondetermenisti action.. An action that will have possible outcome states $Result_i(A)$; where the index i ranges over diff. outcomes.
- Expected Utility

$$EU(A|\mathcal{E}) = \sum_i P(Result_i(A) | Do(A), \mathcal{E})\, U(Result_i(A))$$

where A - Action, $\mathcal{E}$ - All Evidence, $Result_i(A)$, U - Utility.
Do(A) - Proposition that A is executed.

- Maximum Expected Utility: A rational agent should choose action that maximizes expected utility.
- If an agent maximizes, ~~the~~ utility f^n that correctly reflects the performance measure by which its behaviour its been judge, then it will achieve highest possible performance ~~by~~ score if we avg. over environments in which the agent could be placed.

Basis of utility Theory

Lottery - Is a probability distribution over a set of actual outcomes.
+ A lottery 'L' with possible outcomes $C_1, \dots C_n$ occuring with prob. $p_1, \dots, p_n$ is written as.

$$L = [p_1, C_1; p_2, C_2; \dots p_n, C_n].$$

X - The primary ~~utility~~ issue for utility theory is to understand how preferences betw complex lotteries is related to underlying states in those lotteries. i.e., how ~~the~~ ~~a~~ state(s) in a complex lottery gives more utility/preference to its lottery compare to state(s) ~~for~~ of other ~~com~~ complex lottery.

G.K
[+ Lotteries are of 2 types.
+ Simple: ~~The participants are~~ ~~there is a~~ Contains ~~only~~ processes where ~~the p~~ each process is independent of previous process, and the participants are rewarded by chance
+ Complex: contain series of processes, where only in the first process of series the participants are rewarded only by chance, ~~the~~ In subsequent processes, the rewarding is based on chance & outcome of previous process.]
- There are 6 ~~preference~~ constraints in Utility theory.

- Utility Principle:-
If an agent's preferences obey the axioms of utility, then there exists a real value f^n U that operate on states, such that $U(A) > U(B)$ iff. A is preferred to B, & $U(A) = U(B)$, if the agent is indifferent betw ~~to~~ A & B.
- Maximum Expected Utility Principle. (2nd defn)
The utility of a lottery is the sum of probability of each outcome times the ulitity of that outcome.
$$U([p_1, S_1; \cdots ; p_n, S_n]) = \sum_i p_i U(S_i)$$
- Monotonic preferences: Preferences made only on the basis of a particular basic thought/ perspective/ reasoning.
- Risk-averse agent: They prefer a sure thing with a pay-off that is less then expected monetary value of a gamble.
- Certainty Equivalent: The value that an agent can accept in lieu of a lottery.
- Insurance premium:- Diff Betw expected monetary value of a lottery & its certainty equivalent.

- Value f^n / Ordinal Utility f^n: An agent in a deterministic env has a value f^n / ordinal utility f^n + Provides ranking of states rather than numerical values

- $U_\top$: Utility with ~~p~~ best possible prize.
- $U_\bot$: Utility with worst possible catastrophe
- Normalized utilities: Utilities with scale $U_\top = 1$ & $U_\bot = 0$.
- Standard lottery: $[U_\top : p ; U_\bot : (1-p)]$.
- Utilities of intermediate outcome are assessed by asking the agent to indicate a preference betw the given outcome state S & a standard lottery.

- Multi-attribute utility theory: Outcomes are characterized by 2 or more attributes.

- Dominance: If utility of one outcome of an action is greater than other outcome, than ~~formes~~ former dominates later.
Strict dominance: Dominates over all attributes.
- ~~Sto~~ Stochastic Dominance: (used for continous range of outcomes ~~for~~ of an attribute): If utility
Cumulative Distribution: Measures the prob. that value is less than or equal to any ~~val~~ "established" value.
integrates original distribution
→ + If A_1 stochastically dominates A_2, then the expected utility of A_1 is at least as high of A_2, for monotonically ~~-~~ non-decreasing function.
+ Here A_2 can be discarded.
- X + can be used to make rational descisions.

Preference structure & multi-attribute utility
- Representation Theorems: Used to identify regularities in the preference behaviour

Mutual Preferential Independence (MPI) -
- Each attribute may be important, it does not affect the way in which one trades off the other attribute against each other.
- If attributes $X_1, \dots X_n$ are mutually preferentially independent, then the agent's preference behaviour can be des^c as maximing the f^n $V(x_1, \dots, x_n = \sum_i V_i(x_i)$ where each V_i is a value f^n referring only to the attrib X_i

Decision Networks

Combine Baysein N/w with additional node types for actions & utilities. Returns the action with highest utility

Value of Information

- Information value Theory - Enables an agent to choose what info to acquire.
- Sensing actions acquire info.
  - Affect internal state of an agent
  - Evaluate sensing action by their effect on the agent's subsequent "real" actions
  - Done using Information value theory which involves form of a sequential decision making.

- Ashish R. Gavande