Information Gap Based Decision Theory for Data Mining of Competitive Bidding

Mei-Peng Cheong, Gerald B. Sheblé, and Daniel Berleant
Iowa State University

Problem Statement

- Motivation
  - The dynamic change in power industry necessitates a strategic bidding decision-making system (BDMS)
- Past Work
  - Competitors' bidding strategies are modeled as stochastic optimization problem
  - Assumes fully specified probability distributions (*1st-order uncertainty*)
- Objectives
  - To build a basic bidding data generation model based on dynamic economic systems
  - To data mine the behavior of the competitors' bidding policy using evolutionary technique
  - To develop the most favorable bidding policy based on information discovered
  - To develop an information gap model that handles *2nd-order uncertainty* for cost-benefit justification

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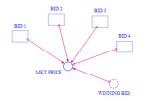
Market Structure



Sealed-Bid, Second-Price Auction

Characteristics of Market Players

- Auction structure
  - Highest bid player wins
  - Market price = second highest bid price
- 4 market players
  - Objective: Maximize profit
  - Assume linear relationship of own risk versus market risk
  - Define private willingness to bid (own risk perception)
  - Capture market signals
  - 1 random bidder

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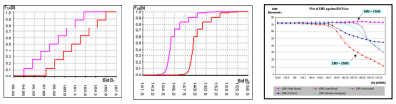
Probabilistic Model



Probabilistic Rival's Bid Functions and Our Own Expected Profits

- Imperfect information leads to uncertainty
- Competitors' bid are modeled as probability boxes (distributions with envelopes)
- A range of Expected Profits (Expected Monetary Values) is derived
- Naïve decision criterion used may result in windfall profits or significant losses
- Need to determine the range of feasible and desirable bids

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Model Description

Data Generation Model (DGM)	
Goal	Generate a generic data set
Input	Market prices, technical constraints, market demand, and supply
Output	A set of bid-quantity prices
Description	A deterministic dynamic economic systems of 4 GenCos in a sealed-bid, second-price auction game

Data Mining Model (DMM)	
Goal	Transform raw data into useful information
Input	Market prices, technical constraints, market demand, and supply
Output	Competitors' bid patterns
Description	An induction process using C4.5 on the output produced with Weka3.2 Java tool

Information Gap Model (IGM)	
Goal	To quantify uncertainty
Input	Heuristic or experts knowledge, historical data, minimum reward level, and bidding policy
Output	A range of feasible bids with their Expected Monetary Values
Description	Defines a robustness function, that returns the greatest value of uncertainty parameter, α

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PROJECT RESULTS

Decision Tree (Rule Induction Process)

Critical Reward separates Expected Profit curves into regions

- Data Mining:
  - Rule induction using C4.5 algorithm infers competitor's BID/NO BID strategy
  - Regression analysis using M5 Rule:
    - Forecasts market price
    - Infer rivals' bidding policy
- Information Gap:
  - Defines the feasible range of bids with respect to minimum reward level
  - Justifies the cost-benefit of data acquisition to reduce uncertainty

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Conclusions

- Captures the relationship between competitors' bidding strategy and other driving market factors
- Assists in quantifying severe uncertainty as data mining can be expensive (market data acquisition)
- Helps decision makers to develop preferences, assess risks and opportunities, and seek information, given a minimum required level of reward
- Potential Application
  - Market players such as Investor-Owned-Utilities (IOUs) and players in other business-like industries
  - Market design for policy makers
  - IGM can be modified to suit the needs of other applications in fields such as medicine, intellectual property, and etc.

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Abstract

Since the start of deregulation, many electric utilities and power network companies have undergone and are still experiencing dynamic change in the ways of doing business, from a vertically integrated industry to a horizontally integrated open market system. The operational planning activity of a generation company (GenCo) is no longer a cost-minimizing process, but is now a profit maximizing process subject to physical constraints and market factors. The objective of this research is to develop a strategic bidding decision process that not only considers the technical aspects of unit operation such as capacity limits but also incorporates information about other market participants and the volatility of the market prices. These additional market factors are significant especially in an oligopoly market because they influence the amount of electricity sold and purchased, hence affecting net profit gained. This project proposes an economic model that data mines the available historical and current market data in a deterministic four-market-participant environment. Additional stochastic analysis is performed using the information gap decision theory concept to quantify the uncertainty that arises. The data mining approach can also be justified for information acquisition to reduce uncertainty, hence improving the information gap model.

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