**Summary**

A new decomposition method for bounding the MEU
- **Join graph decomposition for IDs (JGDID)**
  - Approximate inference algorithm for influence diagrams
  - Proposed method is based on the valuation algebra
  - Exploits local structure of influence diagrams
  - Extends dual decomposition for MMAP

**Significant improvement in upper bounds compared with earlier works**

- Translation-based methods
  - Pure/interleaved MMAP translation + MMAP inference
  - Direct relaxation methods
  - mini-bucket scheme with valuation algebra
  - Relaxing non-anticipativity constraint

---

**Decomposition Bounds for IDs**

- **(Definition) Power-sum elimination for a valuation algebra**
  - generalize elimination operator by L-norm

  \[
  \psi(x) = \sum_{x} \psi(x) P(X|Y) \quad \text{over} \quad X
  \]

  \[
  \sum_{x} f(x) = \sum_{x} \psi(x) P(X|Y) \leq \psi(x) P(X|Y) \quad \text{if} \quad \psi(x) P(X|Y) \leq 1
  \]

  with

  \[
  f(x) = \sum_{x} \psi(x) \quad \text{if} \quad \psi(x) P(X|Y) > 1
  \]

  \[
  \psi(x) P(X|Y) = \sum_{x} \psi(x) \quad \text{otherwise}
  \]

- **(Theorem) Decomposition Bounds for IDs**
  - decomposition bounds interchange elimination and combination

  Given an ID \( M \mid (X, \Theta, \Psi) \), the MEU can be bounded by

  \[
  \psi(x) = \sum_{x} \psi(x) \quad \text{over} \quad X
  \]

  \[
  \theta(x) = \sum_{y} \theta(x, y) \quad \text{for} \quad y \in Y
  \]

  \[
  \Delta = \{ \theta(x) \mid x \in X \}
  \]

**Message Passing Algorithm (JGDID)**

- **Algorithm**
  - Input: Influence diagram \( M = (X, \Theta, \Psi) \), initial weights on arcs, and variables \( X \)
  - Output: Upper bounds on the maximum expected utility

**Background – Influence Diagrams**

- A graphical model for sequential decision-making under uncertainty with perfect recall

**Background – Value and Utility**

- Algebraic framework for computing expected utility value (a.a. potential)

**Background – Value and Utility**

- Approximation scheme that decomposes a Join tree by limiting the maximum cluster size

**Experiment**

- **Benchmarks**
  - Proposed methods
    - **GODD**
    - **JGDID**
  - Non-benchmarked methods
    - **WBMIM**
    - **MBE-VA**
    - **MBE-VA-IA**

**Earlier Works**

- **MMAP translation + approximate MMAP inference**
  - Reduction of ID to MMBP
  - **WMBM (Weighted Mini-Bucket with Moment Matching)**

- **Direct methods for bounding IDs**
  - Reduction of ID to Interpreted MMBP
  - **GODD (Generalized Dual Decomposition)**

**Parameters & Acknowledgement**

- **References & Acknowledgement**

---

**Note:**

- This work was supported in part by NSF grants IIS-1528440 and IIS-1528445, and the US Air Force Contract F46722-16-C-0064 and DARPA (Contract #N66001-16-C-40115).