CDL Quantum Hackathon 2021

Solving Maximun Entropy Method as QUBO problem

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Outlook:

a) Maximum Entropy Principle

b) Potential Applications

c) Solving MaxEnt as a QUBO problem

d) Proof of concept

f) Business proposal

Maximum Entropy Principle

General idea of the Principle

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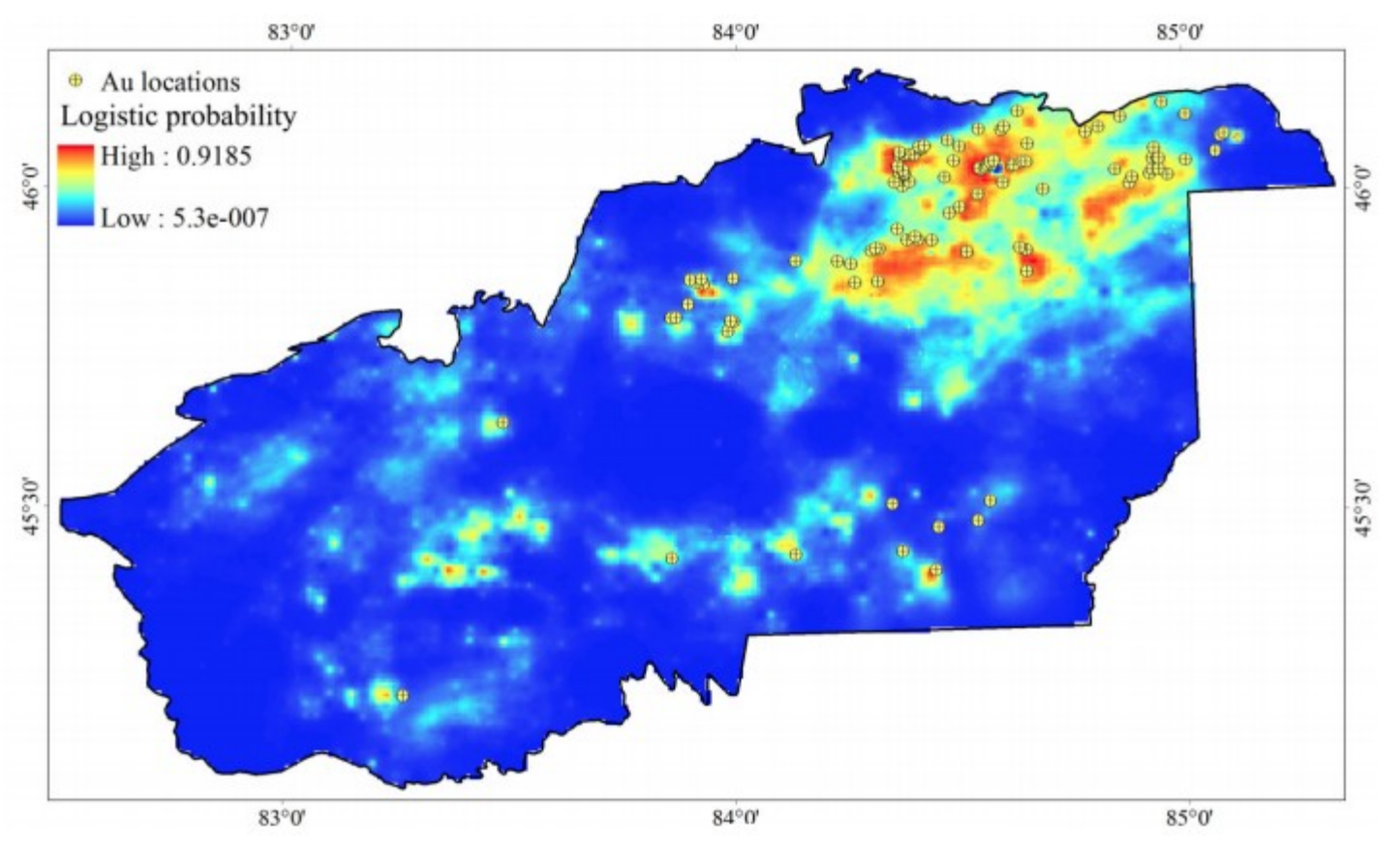
- That is, there is more than one distribution compatible with the available information
- Which one should we choose?
- Jaynes: We choose the one with maximum entropy!

E. T. Jaynes Phys. Rev. 106, 620 (1957).
E. T. Jaynes Phys. Rev. 108, 171 (1957).

Potential Applications



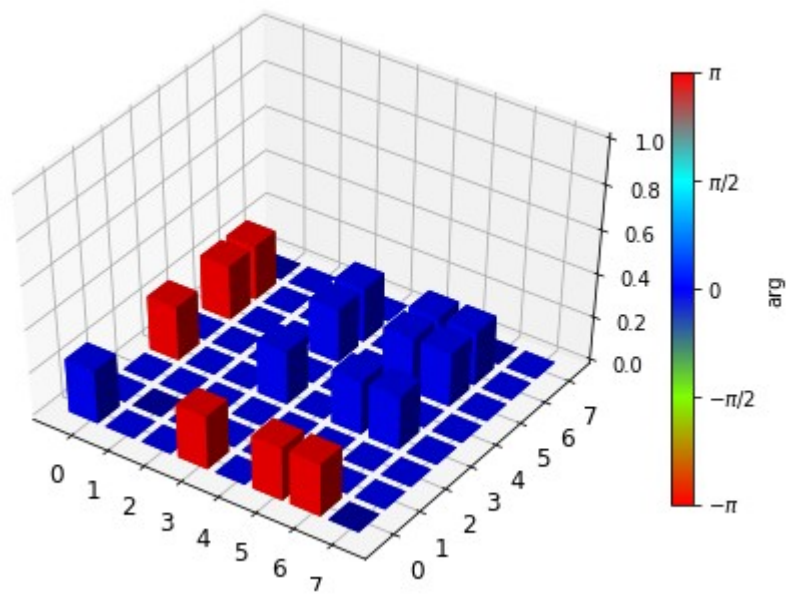
Continuous-scale gold prospectivity map of the Tangbale-Hatu belt generated from MaxEnt model

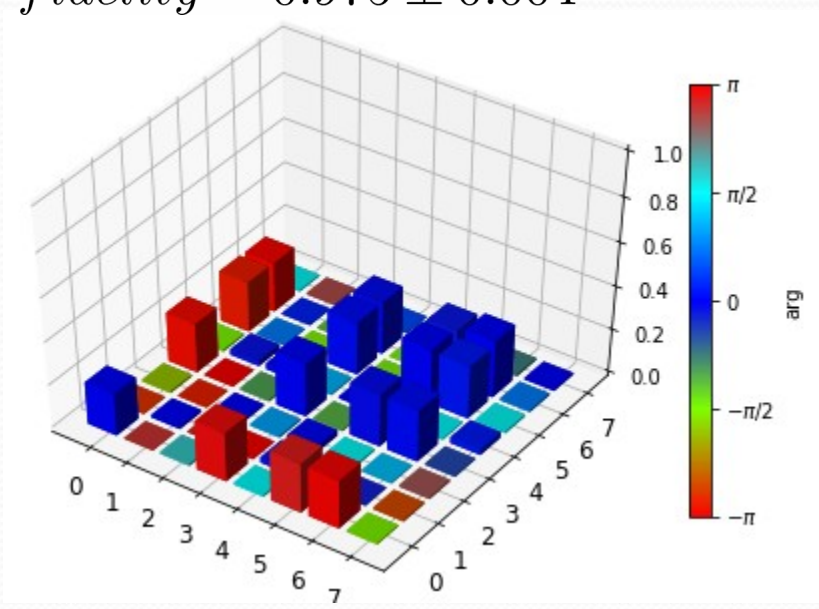
Liu, Yue et. al. Ore Geology Reviews, 100, 133, 2018.

Quantum Systems:

$$|GHZ(\alpha\beta)\rangle = \frac{|\alpha\alpha\alpha\rangle + |\beta\beta\beta\rangle}{\sqrt{2}} \quad \text{with} \quad |\alpha\rangle = \frac{|0\rangle + i|1\rangle}{\sqrt{2}} \quad |\beta\rangle = \frac{|0\rangle - i|1\rangle}{\sqrt{2}}$$

$$fidelity = 0.975 \pm 0.004$$





Quantum Vision Team

Solving MaxEnt as a QUBO problem

MaxEnt formulation:

$$Cost(\bar{p}) = constraints(\bar{p}) + Entropy(\bar{p})$$

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$$Cost(\bar{p}) = constraints(\bar{p}) + \sum_i p_i log(p_i)$$

MaxEnt formulation:

- Change the entropy for a linearized version

$$Entropy(\bar{p}) = 2(1 - \bar{p} \cdot \bar{p})$$

MaxEnt formulation:

- Change the entropy for a linearized version
- Binarize the probabilities

$$p_i = \sum_{i=1}^{Nb} 2^{-i} x_i$$

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$$Cost(\bar{P}) = X^T Q X + C^T X$$

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- Solve with D-Wave system

Proof of concept

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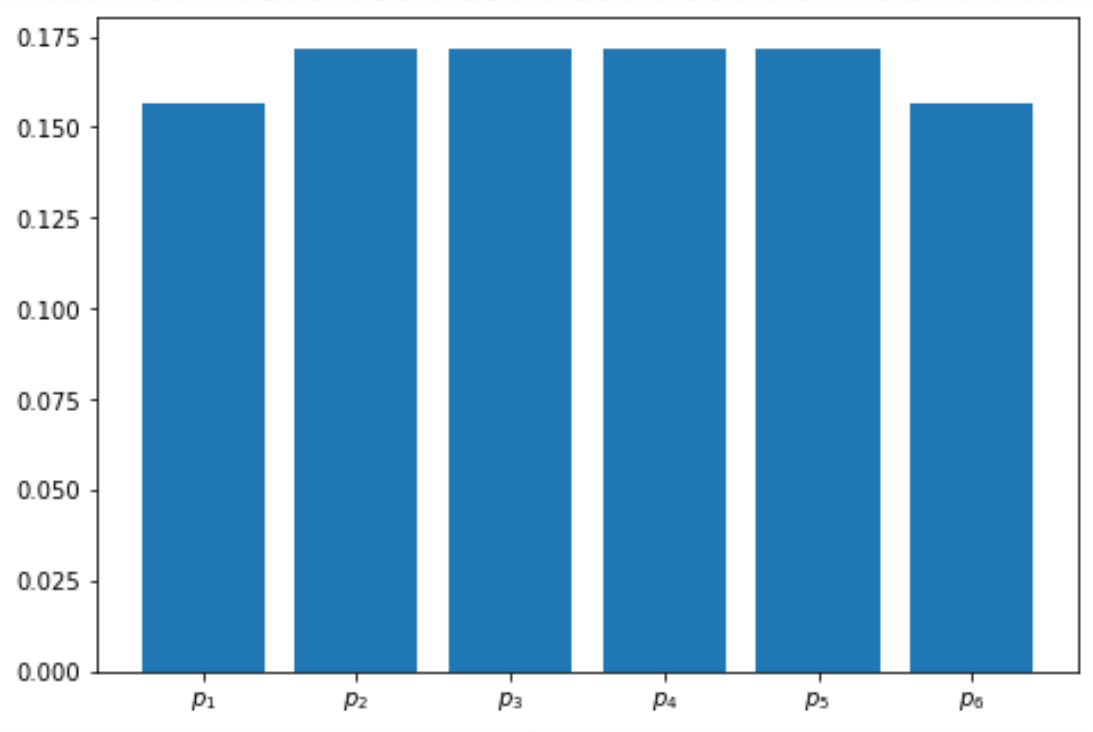
Example 1: with fair mean value

$$\sum_{i=1}^{6} i \; p_i = 3,5$$

Example 1: with fair mean value



Example 2: Loaded dice

$$\sum_{i=1}^{6} i \; p_i = 6$$

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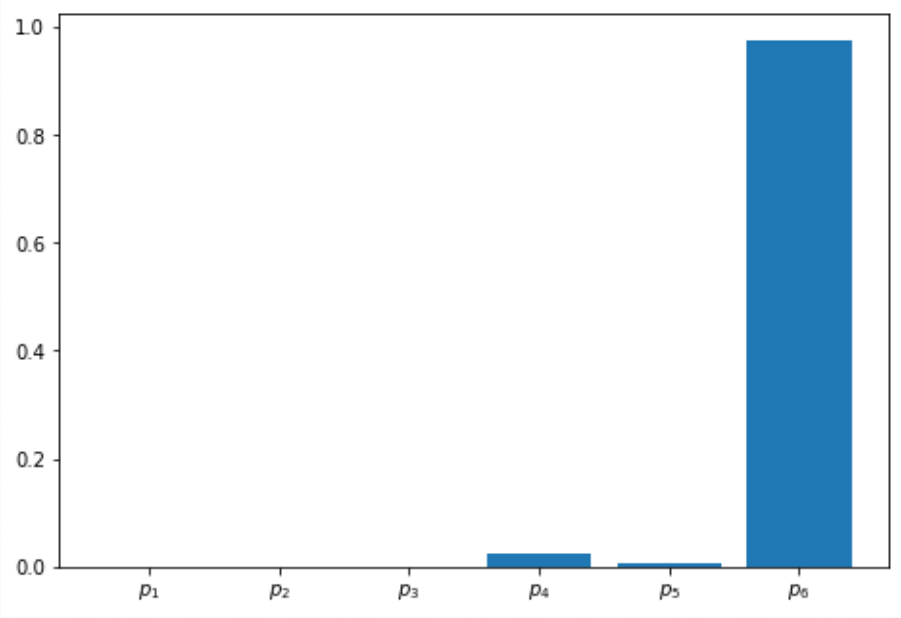

Example 3: Dice with one face with fixed probability

$$p_2 = 0,8$$

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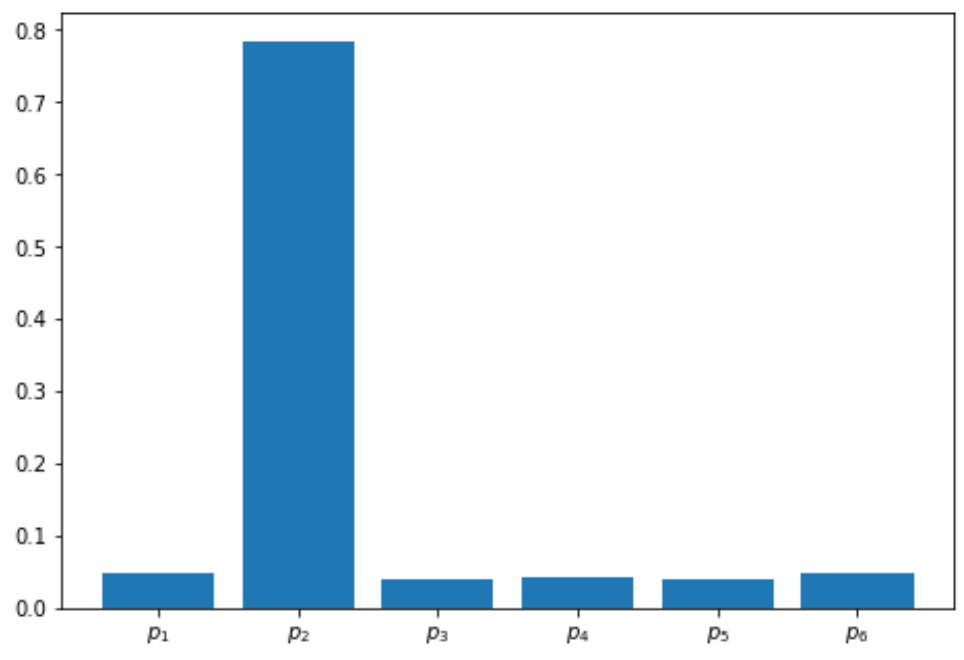

Example 4: Dice with two faces summing a fixed probability

$$p_1 + p_2 = 0,7$$

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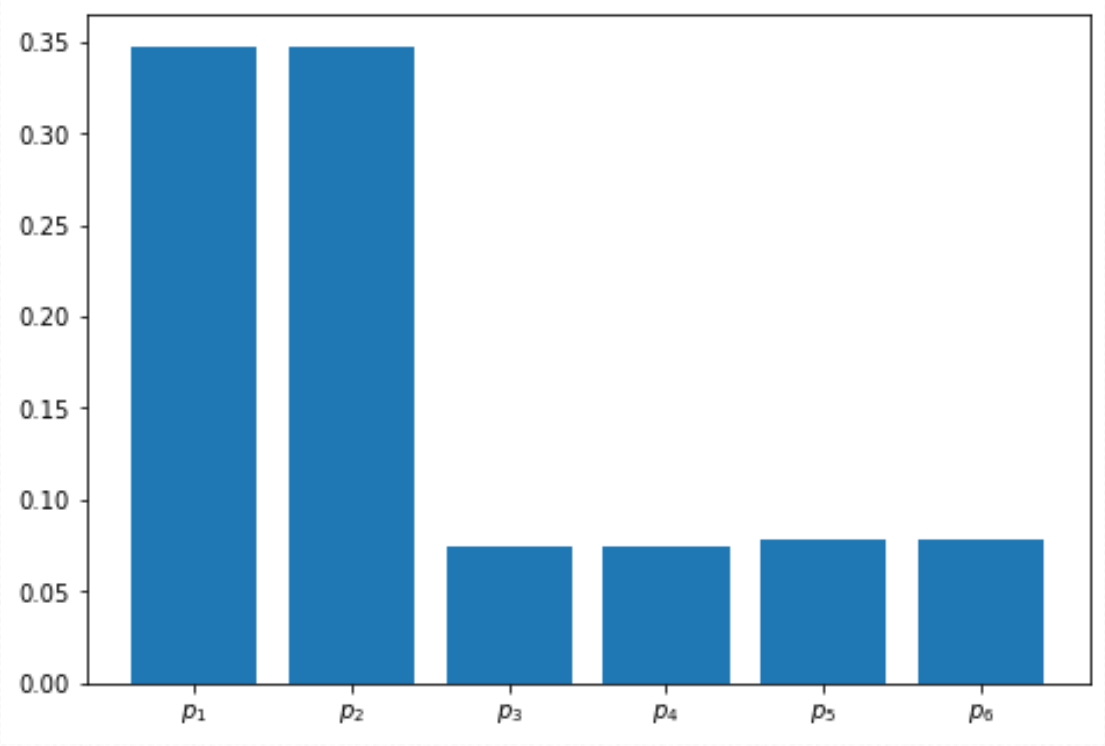

Business Proposal

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- Probabilistic models ready for use.

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- Probabilistic models ready for use.
- Easily implementable set of constrains
- Simple protocol for uploading data
- Simple-setting solvers.

Thank for your atention!