Online-Learning for min-max discrete problems

Beyond COmpetitive Analysis and On-line Learning (BeCOOL)

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For $t = 1, 2, \ldots, T$:

1. The player picks any feasible action $x^t \in \mathcal{X}$.
2. The adversary reveals any objective function $f^t \in \mathcal{F}$.
3. The player suffers loss $f^t(x^t)$.

Cost: $\text{loss}(\mathcal{A}) = \sum_{t=1}^{T} f^t(x^t)$

Benchmark: Minimize the regret, defined as:

$$R_T(\mathcal{A}) = |\text{loss}(\mathcal{A}) - \sum_{t=1}^{T} f^t(x^*)|$$

where $x^* = \arg\min_{x \in \mathcal{X}} \sum_{t=1}^{T} f^t(x)$.
Motivation

1. For linear objectives, any algorithm for the underlying problem translates to a vanishing-regret algorithm for its On-line Learning variant.

2. **Question:** Can similar results be achieved for non-linear objectives?
   - e.g. On-line Learning MinMax Vertex cover.
   - Action $\rightarrow$ Decide a vertex cover on a static graph.
   - Adversary $\rightarrow$ Reveals the weights of the vertices.
   - Cost $\rightarrow$ The weight of the "heaviest" vertex on the cover.
What we have done:

1. Hardness results on the regret of any algorithm for the family of non-linear On-line Learning problems, called *MinMax problems*.

2. Separate the power of *FTL*-based methods and *GD*-based methods for On-line Learning in the case of non-linear objectives.

3. Apply the FTL method for an On-line Learning version of the *Knapsack Problem*. 

Thank you!