

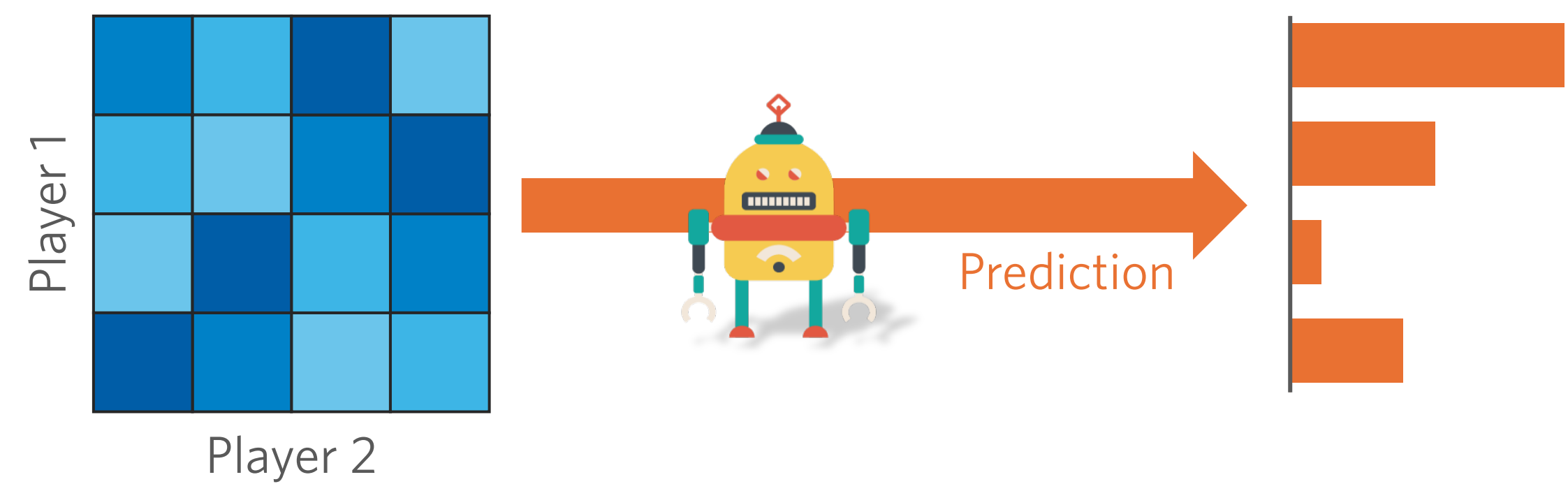
ElementaryNet: A Non-Strategic Neural Network for Predicting Human Behavior in Normal-Form Games

Greg d'Eon, Hala Murad, Kevin Leyton-Brown
University of British Columbia

James R. Wright
University of Alberta

Behavioral Game Theory

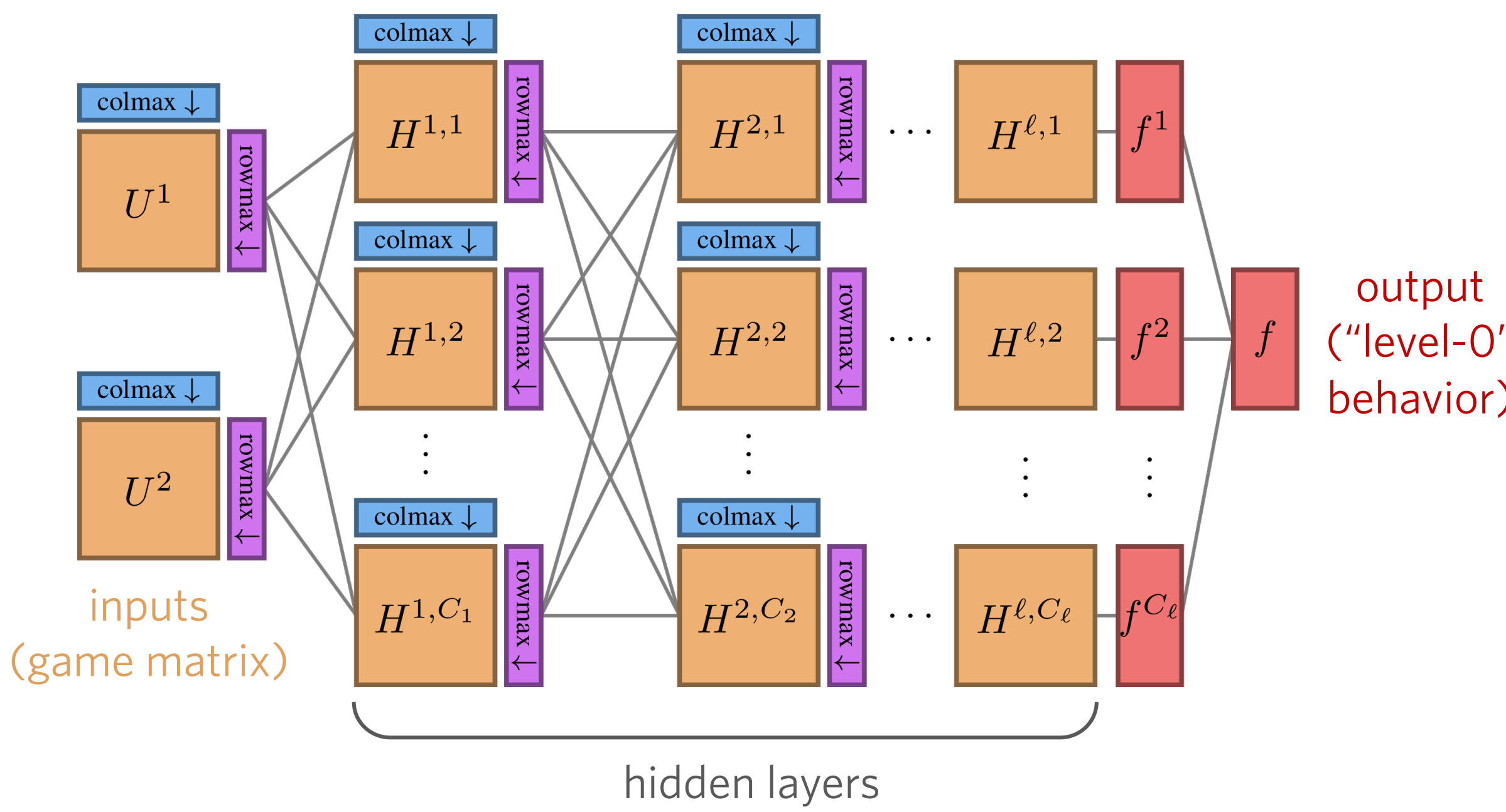
Behavioral game theorists develop models that predict the **distribution of human play** in arbitrary normal-form games



Some models aim to trade off performance with simplicity:
e.g., Poisson quantal cognitive hierarchy (QCHp)
(Camerer et al., 2004)

- "Level-0": uniform random (non-strategic)
- "Level-k": quantal best response to lower levels (strategic)
- Good performance \Rightarrow insights about **human cognition**

Other models aim purely for performance:
e.g., GameNet uses a **neural network** to model "level-0" play
(Hartford et al., 2016)



Surprising result: GameNet performs best when it has **no strategic reasoning model!**

- Is iterative reasoning a **bad model** after all?
- Or, is GameNet's neural network so flexible that it can **emulate strategic reasoning?**

GameNet is Strategic

To answer these questions, we consider a precise definition of strategic behavior (Wright and Leyton-Brown, 2022)

- Intuition: a model is strategic if it **forms a belief** about the opponent's behavior, then **responds to that belief**
- A non-strategic model either does not form a belief, or forms one but does not respond to it

Under this definition, we show that GameNet can represent strategic behavior:

Theorem. GameNet's neural network can approximate a strategic model—quantal best response to maxmax—to arbitrary precision.

The proof is constructive: we describe a specific 3-layer network that does so



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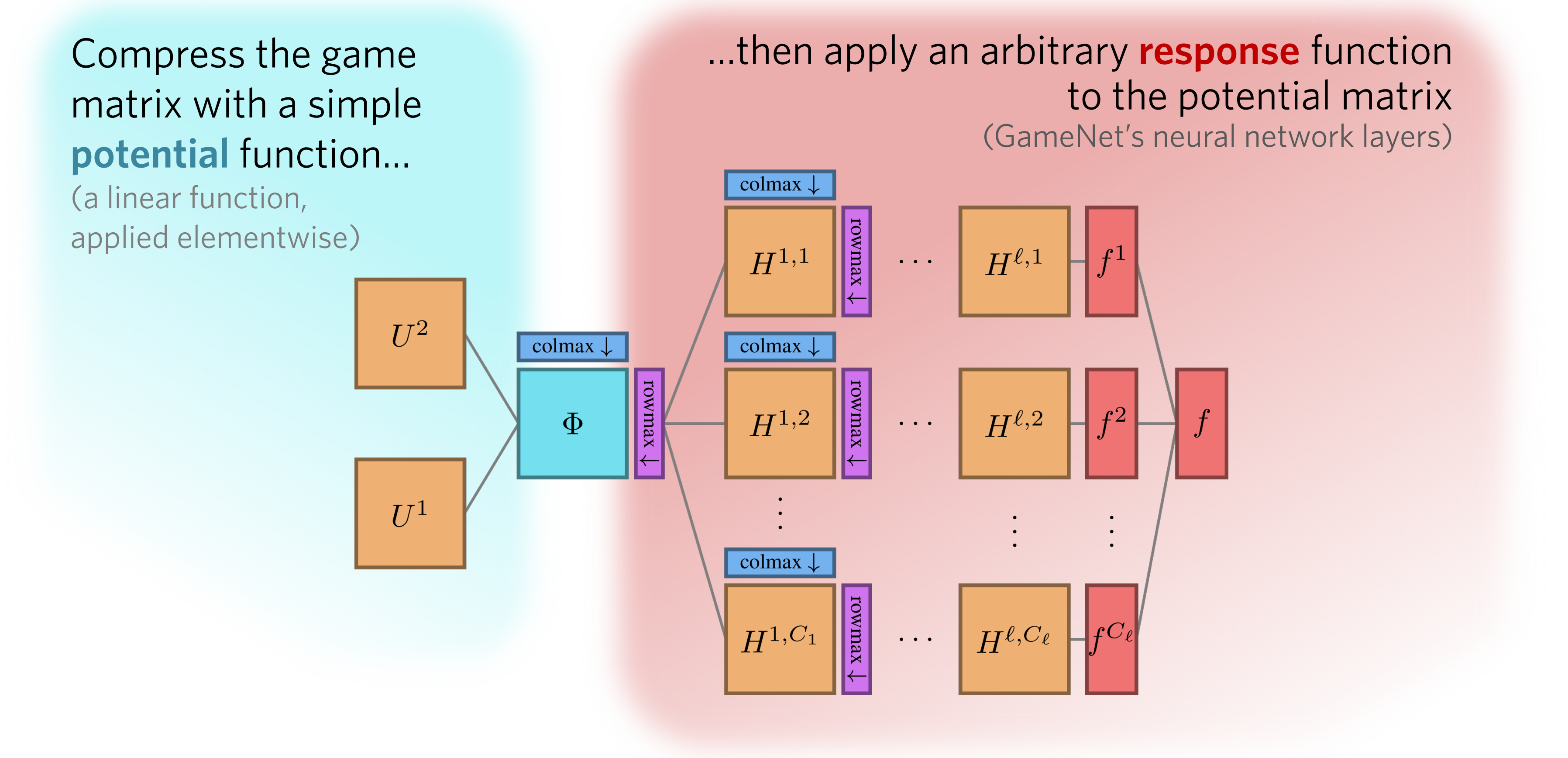


Code



ElementaryNet

We introduce a new architecture based on **elementary models**, a family of models which are provably incapable of representing strategic behavior
(Wright and Leyton-Brown, 2022)



Theorem. ElementaryNet is non-strategic.

Intuitively, the potential function adds a bottleneck that makes it impossible to **both form and respond** to a belief, regardless of the flexible response function

Empirical Results

