



N u k k A I
BRIDGING THE GAPS

Pourquoi s'intéresser à l'IA hybride ?

Véronique VENTOS, Head of Research

...TIME TO TAKE NEXT STEP ?

Common AI approaches still have many flaws :

- Poor human-machine interaction
- Black box
- Energy consuming
- Not adapted to most "real life" situations

=> Most complex problems are beyond these AIs' reach.

"If the only tool you have is a hammer, you tend to see every problem as a nail"





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AI AS "AGGREGATED INTELLIGENCE"

NEXT GENERATION AI

The Challenge for AI in the years to come is to create algorithms that :

- Collaborate with humans
- Are explainable
- Are Energy efficient



Véronique Ventos
Co-founder



Jean-Baptiste Fantun
Co-founder

=> Hybrid AI combining different AI paradigms is the answer to this exciting Challenge

*"To Veronique and Jean-Baptiste:
Good luck building Hybrid, Interpretable AI. It's
what the world needs !"*

Pr Gary Marcus, 2020





WHY BRIDGE ?

A NEW FRONTIER FOR AI

Our sandbox is **the game of Bridge**

Still resists to « classic » AI
⇒ Need of an **hybrid AI system**

GATHERING THE BEST

AN EXCITING PLACE FOR TOP AI TALENTS

We provide a unique environment where people from different AI communities communicate and collaborate efficiently.



Our ambition is to become a leader in Hybrid AI

Véronique Ventos has been ranked by Forbes in 2020 **3rd among the Women Defining the 21st Century AI Movement**



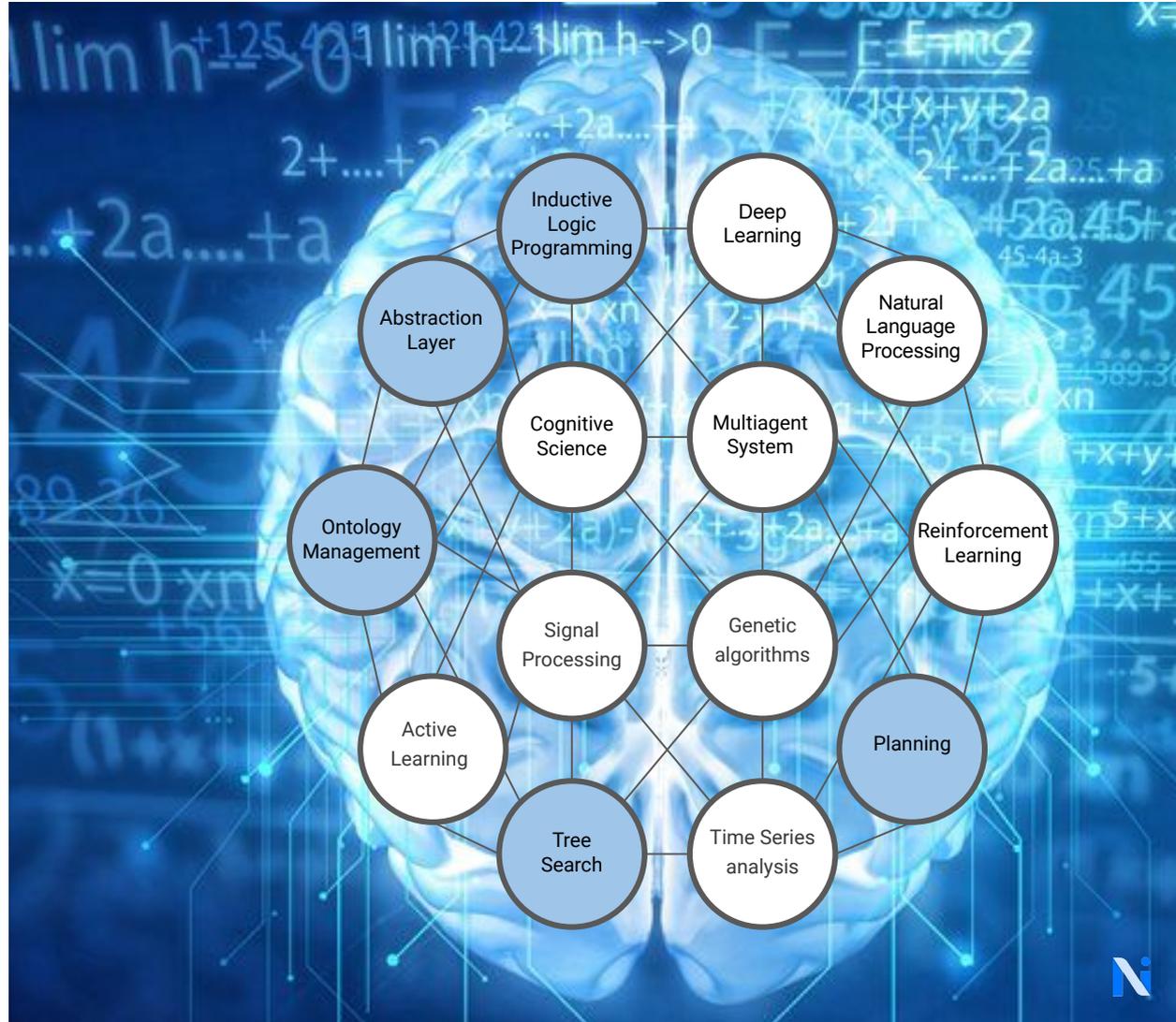
4 YEARS OF INTENSIVE R&D

VERY STRONG TECHNOLOGICAL BASE

Our approaches combine modules based on different AI paradigms to provide the most efficient solution and explanations that are adapted to the user's problem.

We develop proprietary technology to build generic AI modules when scalable on-the-shelf tools are not available.

=> We build a comprehensive AI toolbox that we customize to solve complex problems.

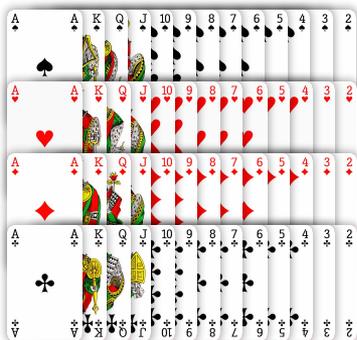




WHAT'S BRIDGE?

A CARD & TEAM GAME

A trick-taking game, played with 52 standard cards opposing 2 pairs of players. Each player only sees his cards.



Incomplete information game
Both collaborative and adversarial





WHAT IS BRIDGE ?

A 2 STEPS GAME

1st step: bidding

coded language used by players to pass information to their partner about their hand

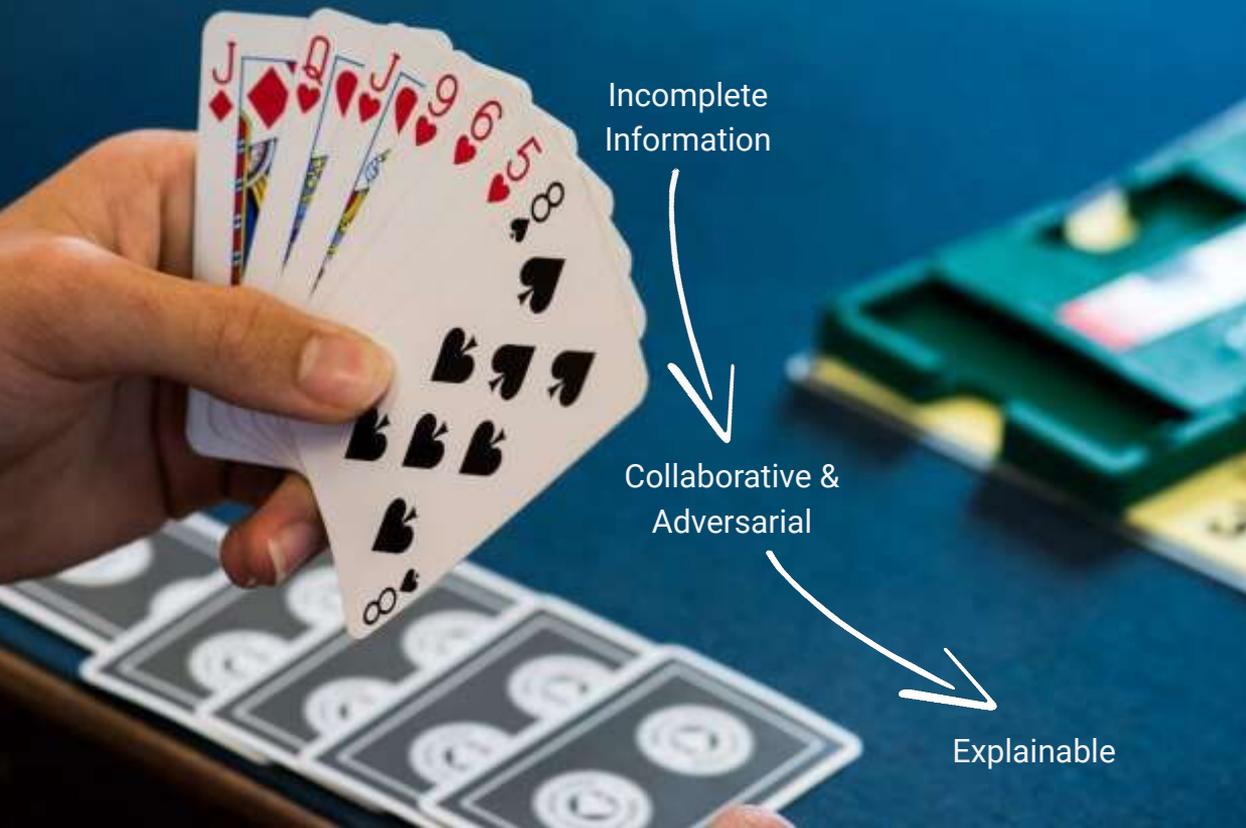
Goal: reach an optimal contract (#tricks and trump)

2nd step: card play

Goal: to fulfill (or to defeat for the defender side) the contract reached during the bidding phase

Challenge: focus on declarer card play

March 24 & 25 at NukkAI and BPI



Incomplete
Information

Collaborative &
Adversarial

Explainable



THE PROOF OF CONCEPT

THE CHALLENGE

Bridge is the game that has most similarities with real life



8 Bridge World Champions came to Paris to face NukkAI's AI

Mastering Bridge would be a significant step towards Artificial General Intelligence



THE CHALLENGE

SAME CONDITIONS

Same cards dealt to each player

Same informations from the 1st step

⇒ Same contract (9⁺ tricks, no trump)

Same deterministic defenders (WBridge5)

⇒ Same lead (1st played card by the defense)

1 board is played 2 times, by 2 different declarers:



by Nook



by a human
champion

x 100 boards/champion

x 8 champions

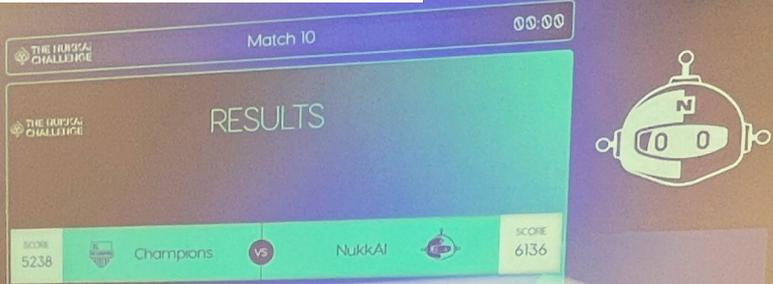
800 results to be compared





NEWSLETTERS - EYE ON A.I.

A.I. conquers bridge, one of the last games to fall to computer brains



March 25-26 2022: 8 Bridge World Champions come to Paris to face NukkAI's AI



HYBRID A.I. CONQUERS BRIDGE

NOOK SUPERSTAR



In a world's first that took place on March 25-26, 2022, our AI Nook beat 8 World Bridge champions.

=> The NukkAI Challenge is a major success for NukkAI's approach of Hybrid AI

Huge media coverage: 3.5 Billion "occasions to be seen" (1 human in 3)

"What we've seen represents a fundamentally important advance in the state of artificial intelligence systems."

(Pr Stephen Muggleton, Imperial College - London)



WHAT IS A HYBRID ARTIFICIAL INTELLIGENCE?

Hybrid Artificial Intelligence consists of...

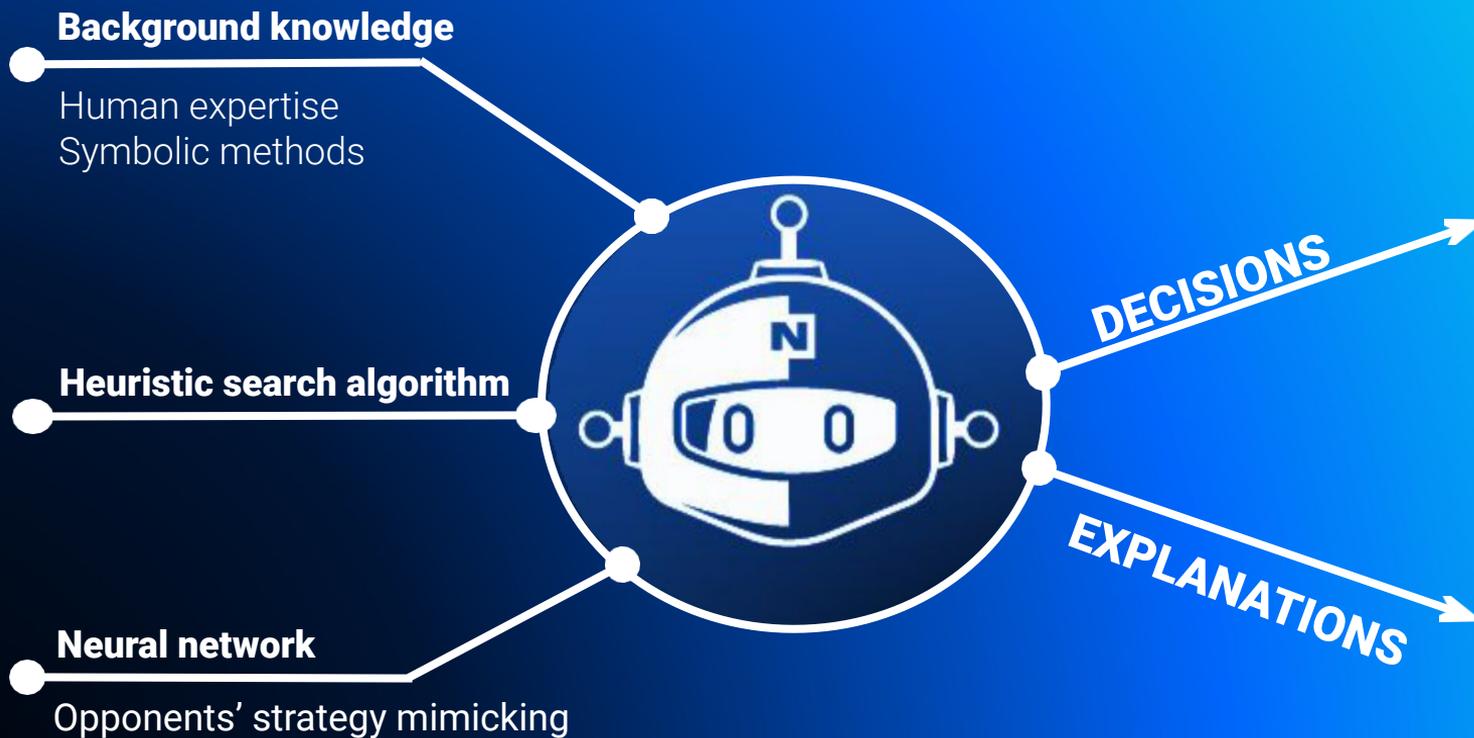


combining approaches from different fields

and when that is not enough to **create new ones**



NEW GENERATION BRIDGE AI



WHY IS NOOK A HYBRID ARTIFICIAL INTELLIGENCE?

Nook is a hybrid AI since it is made up of:

- symbolic rule-based modules
- heuristic search algorithm for incomplete information game
- neural network
- probabilistic module

HOW DID WE MODEL OPPONENTS?

Nook uses several methods to model opponents.

It uses both models in the form of **rules and constraints**, a model in the form of **neural networks** and the **exact model** of the adversary (Wbridge5).

The training of the neural network relies on games that WBridge5 has played against itself.

NOOK IS ENERGY SAVING

Rather than learning by playing a huge number of boards, it begins by **modeling** and **recovering human expertise** in a BK described in **logic**.

NOOK REPRODUCES HUMAN BEHAVIOR

Nook is both **very efficient** and **close to human behavior**

Putting yourself in the place of the opponent who does not have all the informations is necessary in order to reach the top level at bridge.

Nook is made up of **hybrid modules** allowing to make **inferences** against players without perfect information throughout the deal.

WHY IS NOOK CLOSER TO HUMAN BEHAVIOR?

The central module of Nook is an innovative anytime heuristic search algorithm that assumes **imperfect information for the opponents** while previous algorithms were assuming perfect information

Thanks to this new approach Nook is able to make **psychological blows** by imagining mistakes in the opponent rather than assuming that they know everything.

NOOK'S CENTRAL MODULE: ALPHAMU

Nook uses different modules. The central one is based on a variant of the AlphaMu search algorithm published with Tristan CAZENAVE in MCS 2020⁽¹⁾ and COG 2021⁽²⁾.

AlphaMu is an **anytime heuristic search algorithm for incomplete information games** that assumes perfect information for the opponents. Nook uses a variant of AlphaMu that makes inferences throughout the deal.

Nook is with this variant **much more efficient** than our first bot and it is this version that finally made it possible to master the best human players.

(1) https://link.springer.com/chapter/10.1007/978-3-030-89453-5_1

(2) <https://ieeexplore.ieee.org/document/9619088>

NOOK & EXPLAINABILITY

Finally, what is noteworthy is that Nook is able to **provide explanations** related to each decisions. We do not use classical black box approaches since the main goal is to keep human in the loop.

We created an **explainability module** called “what’s on Nook’s mind ?”: this module allows us to show at any time during the board what the high-level vision of our robot is.

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What's on Nook's mind?



NUKKAI PRESENTS THE EXPLAINABILITY MODULE

What is the high-level probabilistic vision of Nook ?

MODULE INTERACTIONS IN NOOK

Nook interacts with modules that automatically generate constraints related to the opponent's strategy. These constraints can be linked to **actions** of the opponent (for example the lead card according to a set of leading rules) and more interestingly by **non-actions** of the opponent (“He did not play the Ace, so he does not have it”).

From a technical point of view, since Nook uses **Monte Carlo simulations**, this allows us to obtain samples of possible worlds that are more relevant.

BRIDGE BOARD

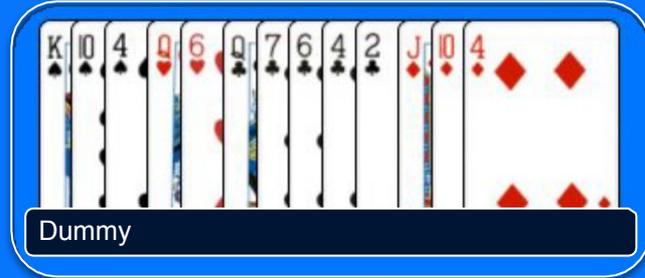
Contract

3NT - 9 tricks

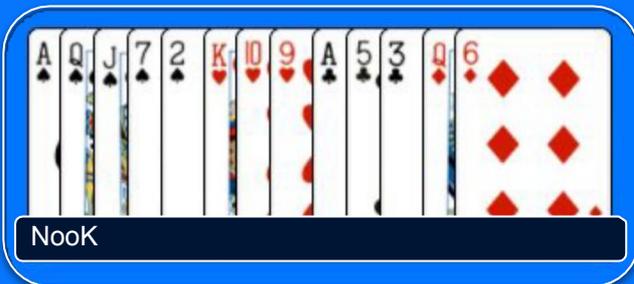
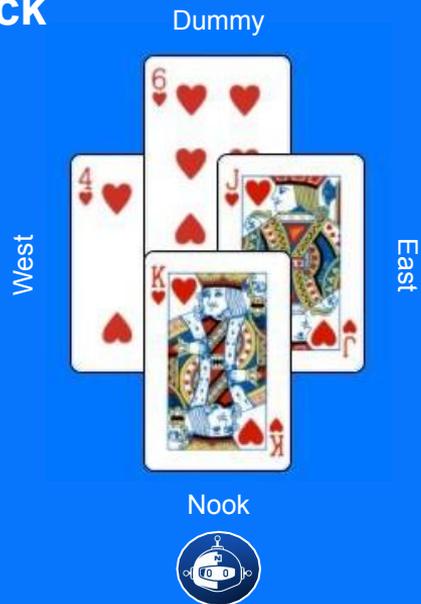
Lead 4♥



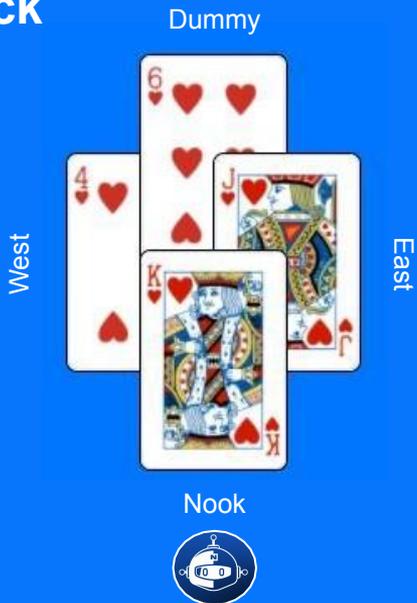
4th best



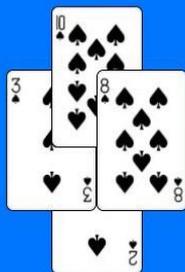
First Trick



First Trick



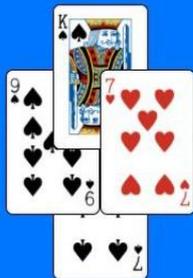
Second Trick



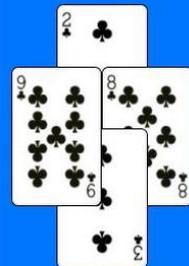
Third Trick



Fourth Trick



Fifth Trick



WHY DID NOOK PLAY LIKE THAT ?



HIGH LEVEL REPRESENTATION OF A HAND

`nb(west,Spade,4)`

`nb(west,Heart,3)`

`nb(west,Diamond,4)`

`nb(west,Club,2)`

`distribution(west,[4,3,4,2])`

To bid or not to bid ?

♠ A 10 6 4
♥ Q 3 2
♦ K Q 10 2
♣ 9 6

North	East	South	West
PASS	PASS	PASS	?

Yes No Oops

A screenshot of a bridge bidding interface. At the top, it asks "To bid or not to bid?". Below that, the hand is shown: Spades (A, 10, 6, 4), Hearts (Q, 3, 2), Diamonds (K, Q, 10, 2), and Clubs (9, 6). Below the hand, there are four columns representing North, East, South, and West. North, East, and South have "PASS" written below them, while West has a "?". At the bottom, there are three buttons: "Yes" (green), "No" (red), and "Oops" (orange). A mouse cursor is pointing at the "Yes" button.

WHAT DOES NOOK KNOW?

❖ East has :
2 cards in Spade

❖ West has :
The As of Heart
The 8 of Heart
The 5 of Heart
3 cards in Spade

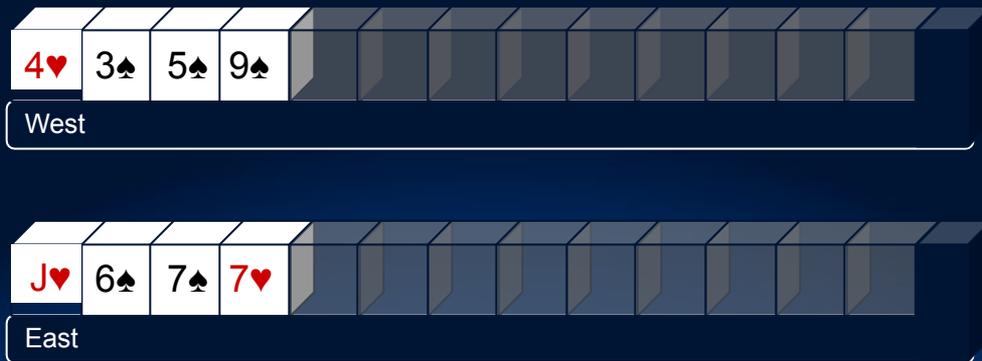
❖ East is likely to have :

- The 9 of Club (76.0%)
- 3 cards in Heart (98.0%)
- 2 cards in Spade and 3 cards in Heart (98.0%)
- 2 cards in Spade and 5 cards in Diamond (74.0%)
- 2 cards in Spade and 3 cards in Club (72.0%)
- 3 cards in Heart and 5 cards in Diamond (72.0%)
- 3 cards in Heart and 3 cards in Club (72.0%)
- 5 cards in Diamond and 3 cards in Club (72.0%)
- a 2353 distribution (72.0%)
- a 2344 distribution (26.0%)

❖ West is likely to have :

- 5 cards in Heart (98.0%)
- 3 cards in Spade and 5 cards in Heart (98.0%)
- 3 cards in Spade and 3 cards in Diamond (74.0%)
- 3 cards in Spade and 2 cards in Club (72.0%)
- 5 cards in Heart and 3 cards in Diamond (72.0%)
- 5 cards in Heart and 2 cards in Club (72.0%)
- 3 cards in Diamond and 2 cards in Club (72.0%)
- a 3532 distribution (72.0%)
- a 3541 distribution (26.0%)

WHAT DOES EVERYBODY KNOW, EVEN WITHOUT ANY INFERENCE?



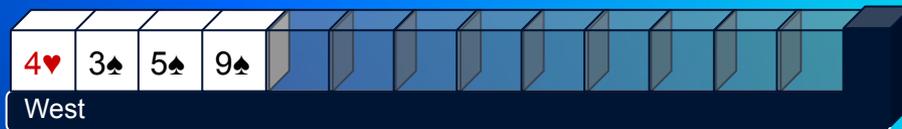
At trick 4  seen cards  unseen cards

NOOK'S INFERENCE

Lead inference

West has 5 ♥
So East has 3 ♥

1



After 3 tricks of Spades

West has 5 ♥ and 3 ♠
So East has 3 ♥ and 2 ♠

2

East has 5 ♦ and 3 ♣ in 72% of Nook's worlds. East has 4 ♦ and 4 ♣ in 26% of Nook's worlds.

NOOK'S INFERENCE

Lead inference

West has 5 ♥
So East has 3 ♥

1



After 3 tricks of spades

West has 5 ♥ and 3 ♠
So East has 3 ♥ and 2 ♠

2

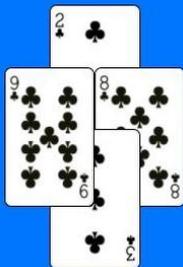
East has 5 ♦ and 3 ♣ in 72% of Nook's worlds. East has 4 ♦ and 4 ♣ in 26% of Nook's worlds.

Conclusion

East has always more ♣ than West.

ADVANCED INFERENCE

Fifth Trick



Genuine inference

K♣ is at 100% in East's hand

With J-10-8, West would have played 10♣ or J♣

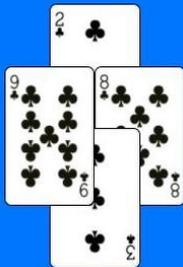
3

Conclusion

He will play ♦ in order to endplay East.

ADVANCED INFERENCE

Fifth Trick



Genuine inference

K♣ is at 100% in East's hand

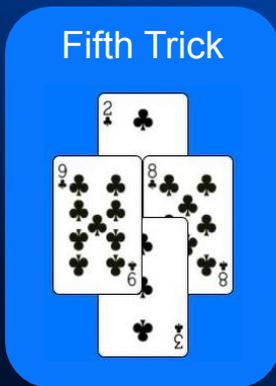
3

With J-10-8, West would have played 10♣ or J♣

Conclusion

He will play ♦ in order to endplay East.

ADVANCED INFERENCE



Genuine inference

K♣ is at 100% in East's hand

3

With J-10-8, West would have played 10♣ or J♣

Conclusion

He will play ♦ in order to endplay East.



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1³⁶

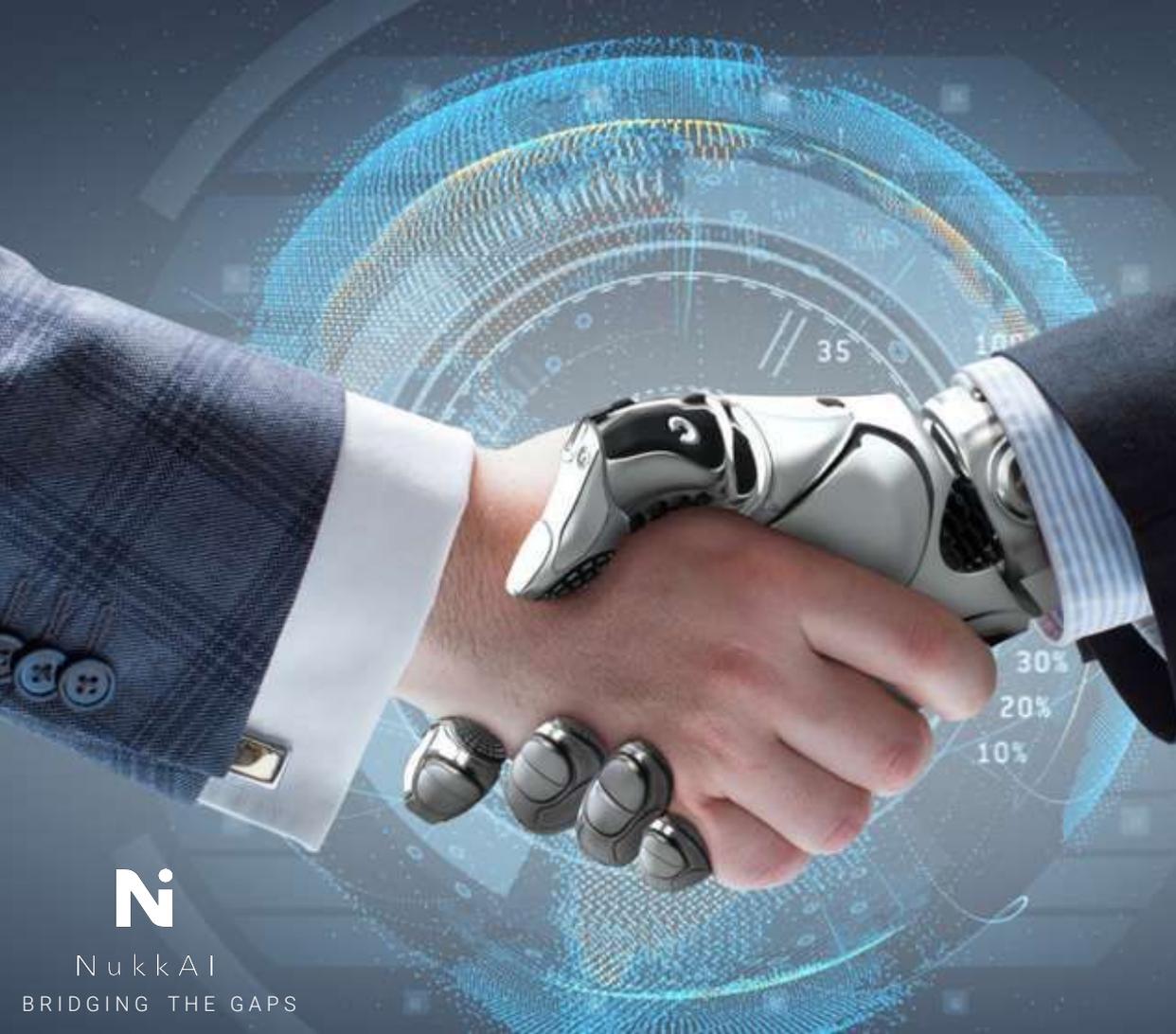
WHAT'S NEXT?

CONCLUSION AND FUTURE WORKS

Nook's victory is a world premiere but there are still many bridge challenges!

Epistemic reasoning
New Monte-Carlo search algorithms using ILP

Transfer to business verticals



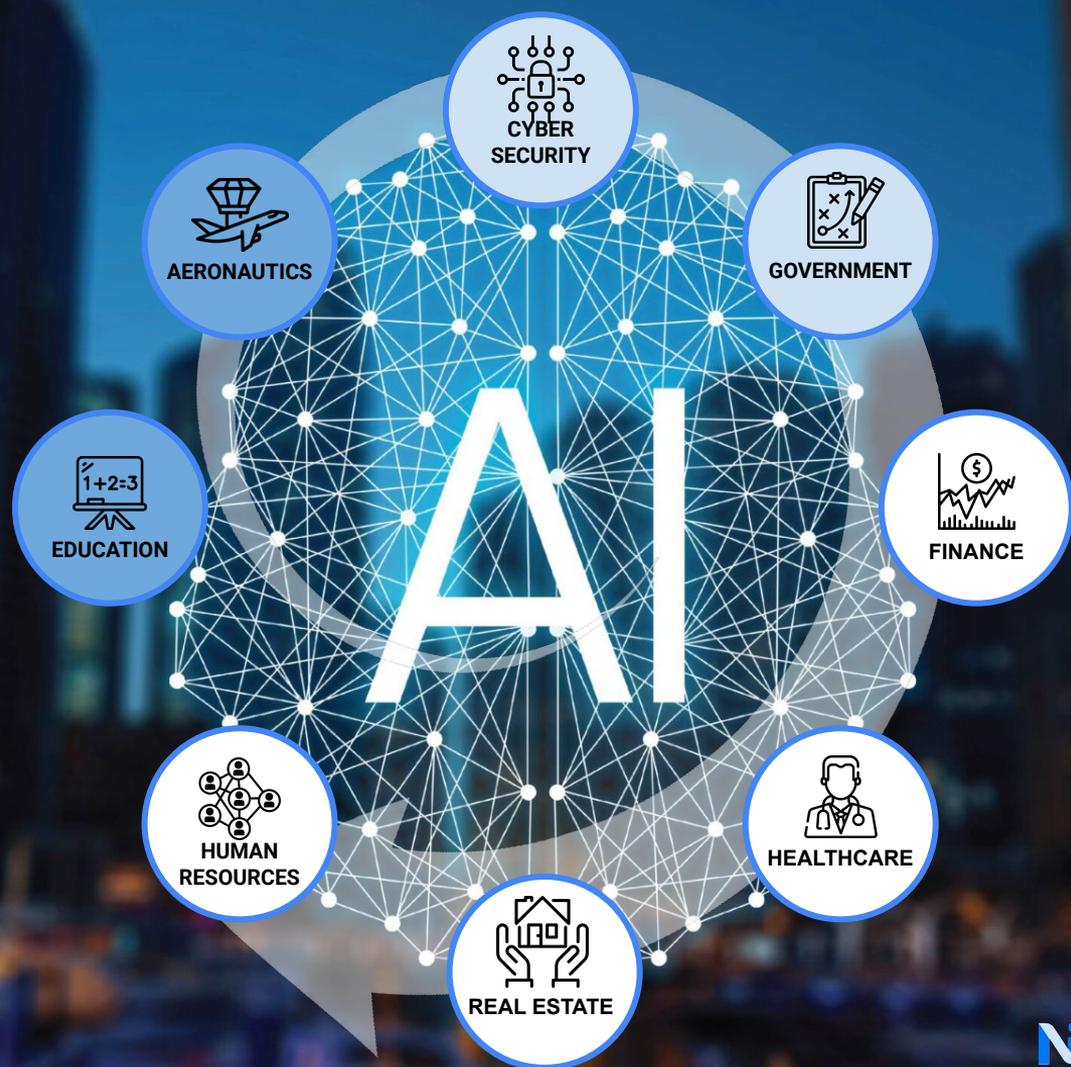
Nuk AI

BRIDGING THE GAPS

A HUGE POTENTIAL

AN IMPRESSIVE PIPE

We have identified many potential applications : Aeronautics, Education, Cybersecurity, Government, Finance etc





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Thank you

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