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# Towards a conceptual framework for designing Symbiotic AI systems

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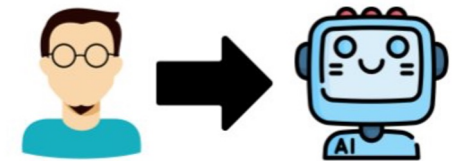


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## Introduction

- *Spoke 6: Symbiotic Artificial Intelligence (SAI)*
  - Lead beneficiary: UNIBA  
PI: Donato Malerba, co-PI: Giovanni Semeraro
- *TP3 “Learning and Reasoning from Individual to Communities to Society”*
- SAI aims to increase human-machine collaboration, augmenting human cognitive abilities rather than replacing them
- WP6.1: Design of SAI systems
  - How to integrate SAI system design with principles and methodologies of Human-Computer Interaction?

### Automation



Replace human intelligence with artificial intelligence.

### Augmentation



Augment human intelligence with artificial intelligence.

Steven M. Moore, “Automation VS. Augmentation in AI: Designing Mixed-Initiative User Interfaces”.



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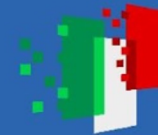
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## Main challenges in designing SAI systems

- System transparency
  - Explanations should be adequate for non-technical people
- User control
  - New interaction paradigms should empower the human to be in control and to modify the system behaviour through a collaboration with the system



## How can we mitigate these challenges?

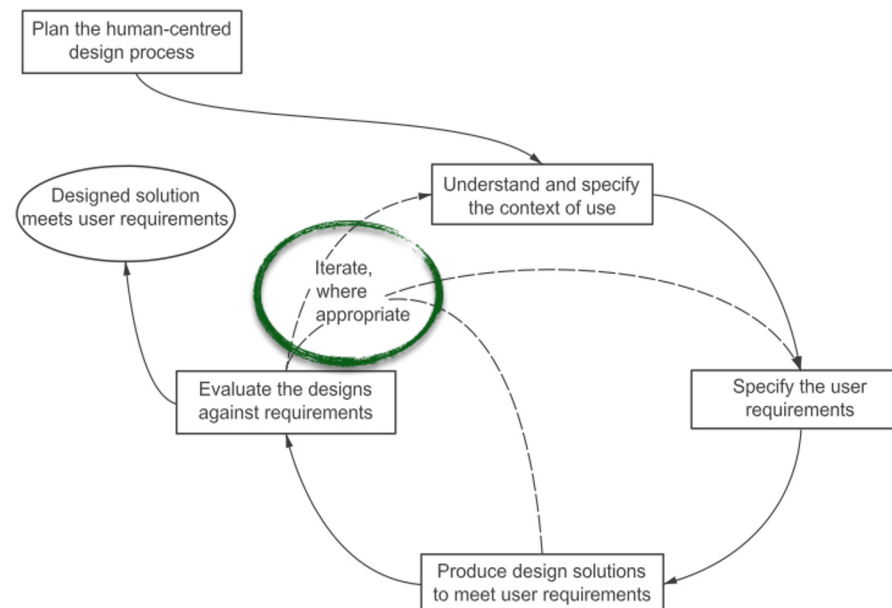
- Shifting the design paradigm from an algorithm-focused view to a human-centered perspective
- Involving users in all the phases of the system design, as suggested by the Human-Centred Design approach, to produce SAI systems that are reliable, safe, and trustworthy

Only possible if  
you:

- involve
- observe
- talk to



the  
user



ISO 9241-210 “Human-Centred Design  
for Interactive Systems”



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## The new Human-AI Interaction Paradigm

- It permits a deeper collaboration between human and AI
- It consists of an iterative negotiation process based on 3 interactions strategies



*Clarification:* the system explains the reasons for its behaviour/decision



*Iterative exploration:* the system outcome is reached through a series of iterative steps between the user and the AI system



*Reconfiguration:* the user is allowed to initiate the retraining of AI models based on user feedback

Desolda G., Dimauro G., Esposito A., Lanzilotti R., Matera M., Zancanaro M. A Human–AI interaction paradigm and its application to rhinocytology. Special issue on Human-Centered Artificial Intelligence for One Health, Artificial Intelligence in Medicine, Vol. 155 (2024).



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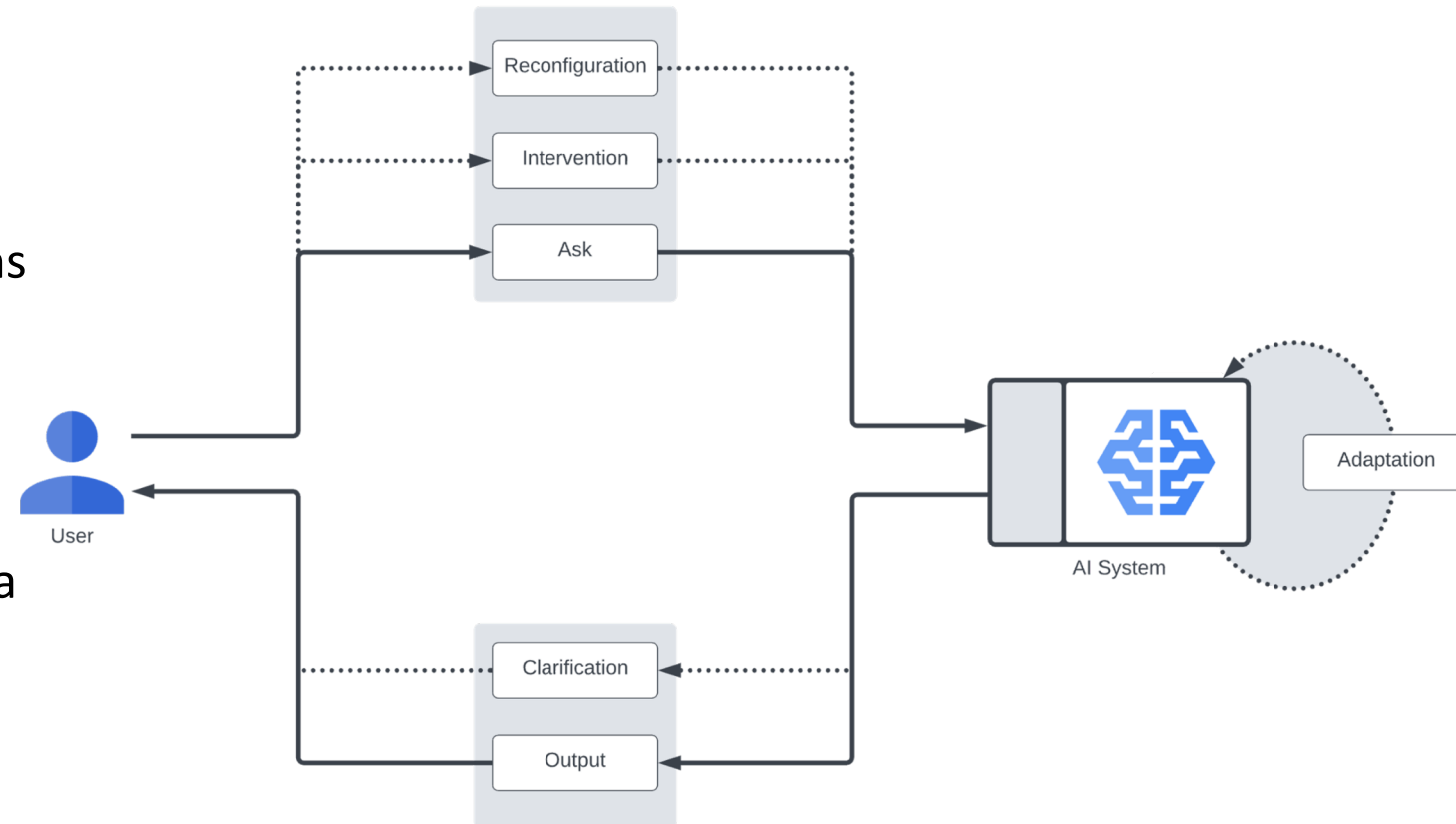
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## The Human-AI interaction model

- Human-AI Interaction paradigm enables a *negotiation process*
- The human not only understands the reasons that determine a specific system behaviour, but also to intervene and modify it through iterative reconfigurations
- The negotiation process is characterized by a sequence of actions, continuous feedback and adaptations







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## Application of the new interaction paradigm

- Healthcare context
  - GOAL: Creating a new version of the Rhino-Cyt prototype, in order to allow rhinocytologists to collaborate with the system for a correct classification of the nasal mucosa cells





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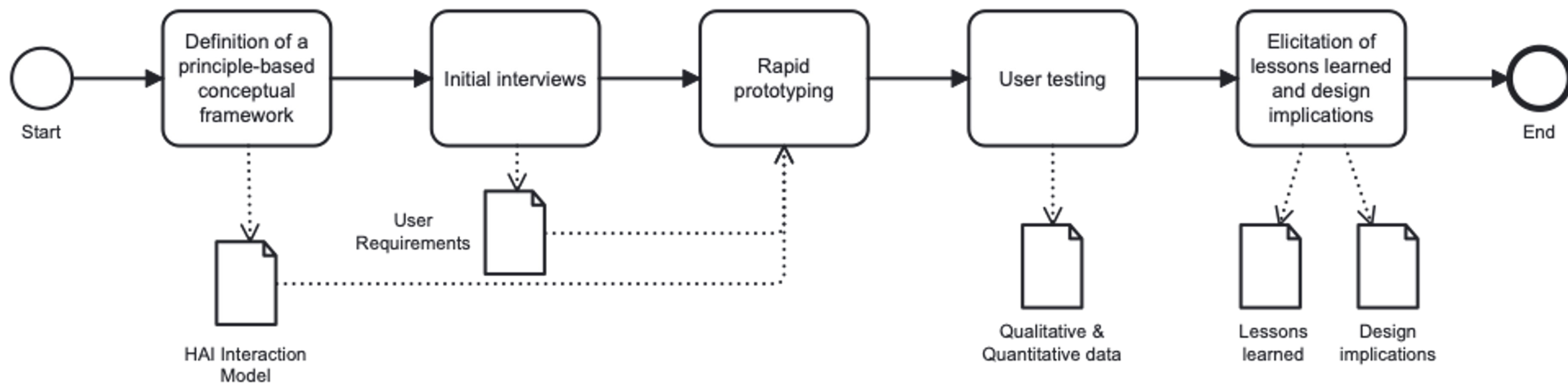


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## Our HCD Process







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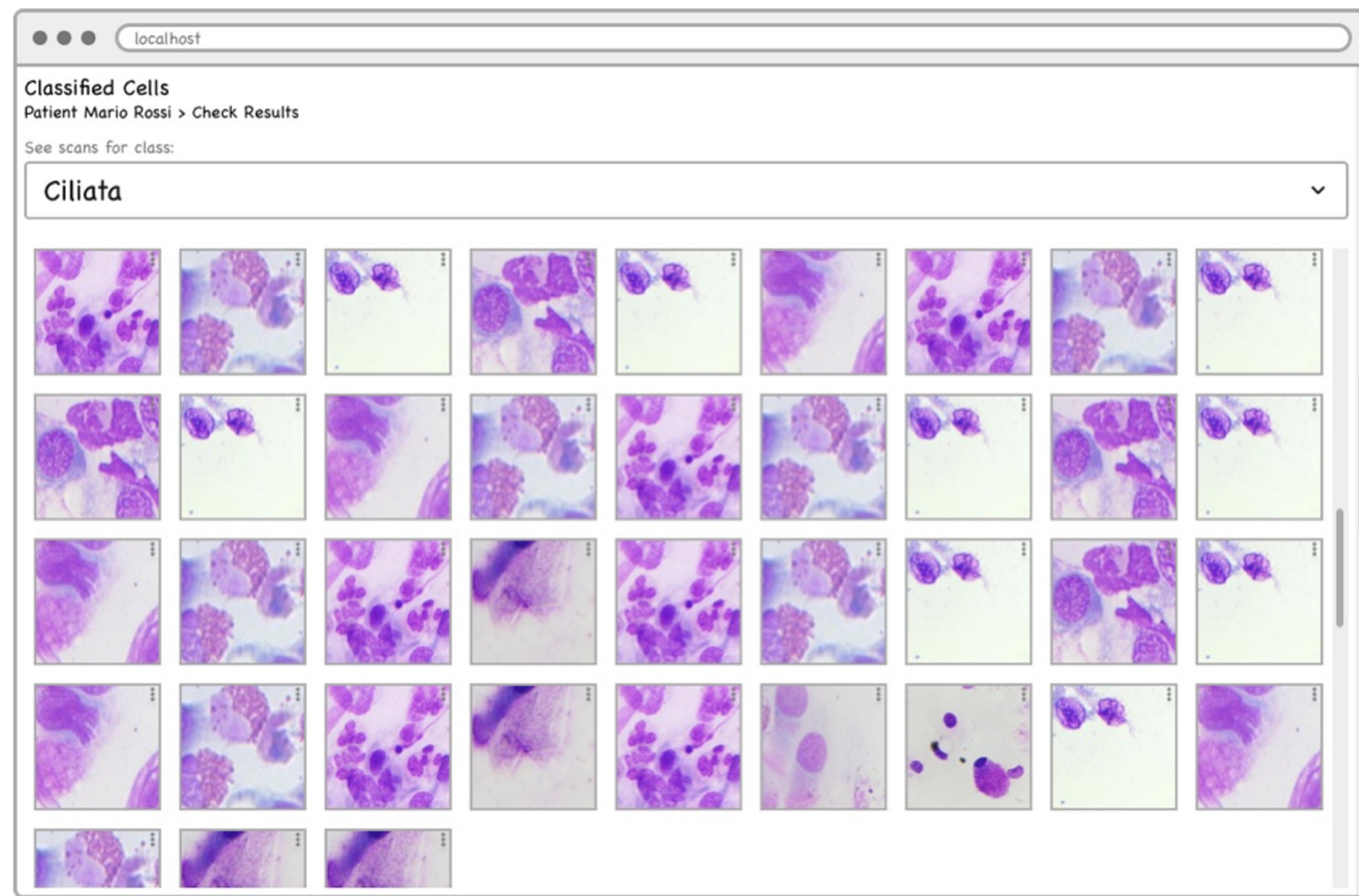
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# The Rhino-Cyt prototype

## "Traditional" version





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# The Rhino-Cyt prototype

## "SAI" version

localhost

Cells by Classification Confidence  
Patient Mario Rossi > Check Results

See scans for class:

Ciliata Count 25

Low confidence Validate All

Medium confidence Validate All

High confidence Validate All

Classified as: Ciliata

☒ Mark as correct ☐ Mark as wrong

Explanation

This cell was classified as "ciliata" because:

- it has a diameter of [X], in range for ciliata [A, B] ☒
- It has cilia ☒
- It has SIS ☒

Counter-Examples

Artifact	Bacteria	Lymphocyte	Neutrophil	Epithelial	Mast
Emazia	Eosinophil	Metaplastic	Muciparous	Muciparous	See More



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# The Rhino-Cyt prototype "SAI" version

The screenshot displays the Rhino-Cyt prototype interface, which is a web application for cell classification. The interface is divided into several sections:

- 1. Classification output with confidence regulating mechanisms:** This section shows a grid of cell images categorized by confidence. The top section is labeled "Low confidence" and the bottom section is labeled "High confidence". A "Validate All" button is present in each section. The top section also shows a "See scans for class:" dropdown menu set to "Ciliata" and a "Count" of 25.
- 2. Classification details:** This section shows a large image of a cell, classified as "Ciliata".
- 3. Intervention:** This section shows a button labeled "Mark wrong" with a checkmark icon.
- 4. On-Demand Editable Explanations:** This section shows a list of explanations for the classification, such as "It has a diameter of [X] in range for ciliata [A, B]".
- 5. Counter-Examples (useful for clarification):** This section shows a list of counter-examples, such as "Eosinophil", "Metaplastic", "Muciparous", and "Muciparous".

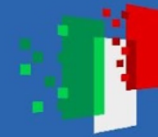




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## Evaluation study

- Goal: Evaluating the new interaction strategies that allow rhinocytologists to collaborate with the SAI system
- Participants: 9 rhinocytologists
- Design: Within-subjects design  
(Traditional vs SAI)
- Used techniques
  - Direct observation with the Thinking-aloud protocol
  - Questionnaires:
    - NASA Task Load Index (NASA-TLX) - Workload
    - Unified Theory of Acceptance and Use of Technology (UTAUT) - Acceptability
    - Trust in Automated Systems Test (TOAST) - Trust
  - Content analysis of video recordings - User experience





## Evaluation study – Results of Quantitative data

- Workload: No significant difference emerged

	NASA-TLX		Mental Demand		Physical Demand		Temporal Demand		Performance		Effort		Frustration	
	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn
<b>Classic</b>	25.00	21.70	36.66	30.00	24.44	20.00	28.88	20.00	15.55	10.00	26.66	20.00	17.77	10.00
<b>Redesigned</b>	23.70	21.70	33.33	30.00	18.88	20.00	25.55	20.00	14.44	10.00	34.44	20.00	15.55	10.00
<b>w-Test</b>	$Z = -0.2$ $p = .859$ $r = -0.06$		$Z = -0.5$ $p = .608$ $r = -0.2$		$Z = -0.9$ $p = .395$ $r = -0.3$		$Z = -0.09$ $p = .931$ $r = -0.03$		$Z = -0.3$ $p = .766$ $r = -0.1$		$Z = 0.3$ $p = .792$ $r = 0.1$		$Z = 0$ $p = 1.000$ $r = 0$	

- Acceptability: No significant difference emerged

	TAM		Performance Expectancy		Effort Expectancy		Attitude Toward Using Technology		Behavioral Intention to Use the System		Self-Efficacy		Social Influence	
	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn
<b>Classic</b>	3.87	4.00	3.7	4.0	4.5	4.5	4.2	4.5	3.8	4.3	4.4	4.8	2.5	2.5
<b>Redesigned</b>	3.98	4.20	4.0	4.5	4.6	4.8	4.6	4.8	3.9	4.3	4.4	4.5	2.9	3.0
<b>w-Test</b>	$Z = 0.4$ $p = .676$ $r = 0.1$		$Z = 0.7$ $p = .514$ $r = 0.2$		$Z = 0.3$ $p = .752$ $r = 0.1$		$Z = 0.7$ $p = .512$ $r = 0.2$		$Z = 0.2$ $p = .833$ $r = 0.07$		$Z = 0.2$ $p = .833$ $r = 0.09$		$Z = 0.2$ $p = .833$ $r = 0.09$	





## Evaluation study - Results of Quantitative data

- Trust: No significant difference emerged

	TOAST		Reliability		Transparency	
	$\bar{x}$	Mdn	$\bar{x}$	Mdn	$\bar{x}$	Mdn
<b>Classic</b>	5.69	5.87	5.97	6	5.42	6
<b>Redesigned</b>	5.75	6.00	5.94	6	5.55	6
<b>W-test</b>	$Z = 13$ $p = .547$ $r = 0.2$		$Z = -0.07$ $p = .944$ $r = -0.02$		$Z = 0.2$ $p = .866$ $r = 0.06$	



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## Evaluation study - Results of Qualitative data

- The implemented strategies are valuable
- Participants seem to trust the SAI version of Rhino-Cyt
- It is important to offer explanations that can be customized and accessed “on demand”
- Useful lessons for AI in medicine are learned
  - Explanations must be expertise-driven
  - Let users customizing explanations
  - Intervention is needed
  - Localize explanations
  - Allow transparent learning
  - Consider experts knowledge limitations
  - Mitigate risks to human values
  - Efficiency and objectivity drive adoption



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**Thank you for the attention!**

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