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Linking Computerized and Perceived Attributes of Visual Complexity

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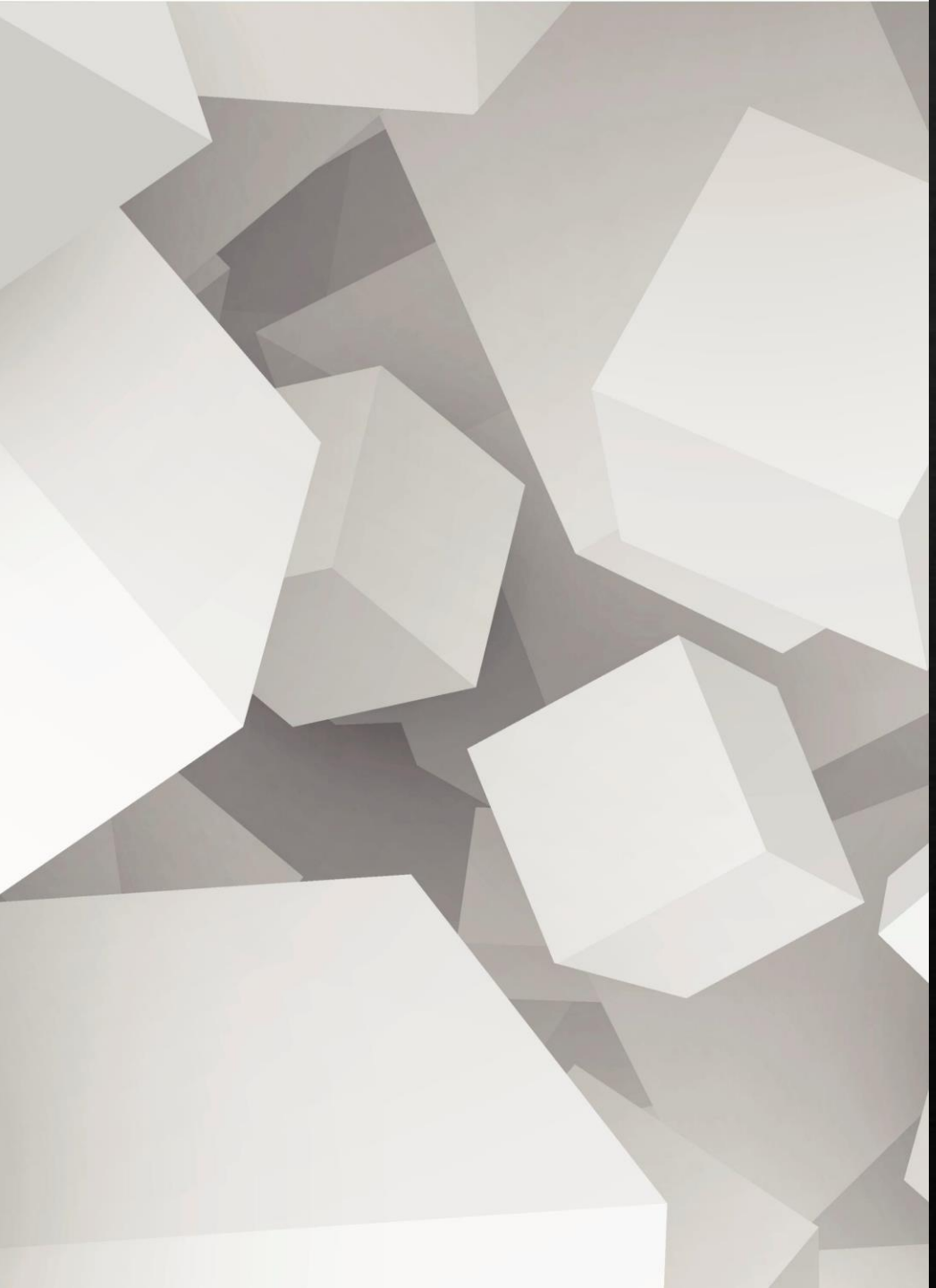
About the Presenter

Kanaka Babshet
MSc(Eng) University of the Witwatersrand, South Africa

Completed an MSc(Eng), part-time, at the end of 2019, encompassing machine vision and cognitive psychology.

Also recently started a new job as a Product Owner at an online shopping start-up named OneCart in South Africa.

Thrives in an environment where behavioural psychology can be explored through customer insights and data strategies.



Presentation Outline

Cognitive Assessments

Objective

Approach and Implementation

Results

Conclusion

Visual Perception in Cognitive Assessments

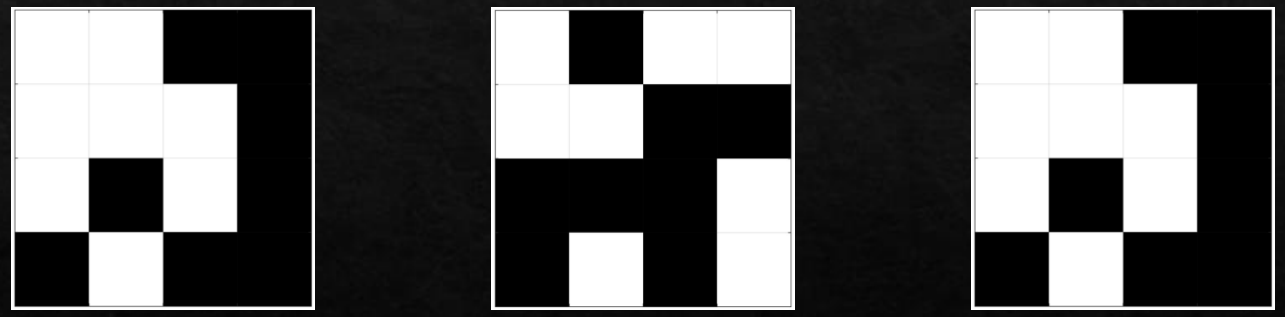
- Cognitive assessments often use visual stimuli to detect neurocognitive decline
- However, there are assessment concerns:
  - Subjective complexity definitions
  - Limited dataset through manual testing
- This necessitates a computerised complexity scale for an objective performance evaluation
- Current hindrance: visual perception is studied separately in the fields of cognitive psychology, and computer vision

Objective

Find a set of computed attributes, or features, which could help explain the complexity of a cognitive task associated with visual stimuli.

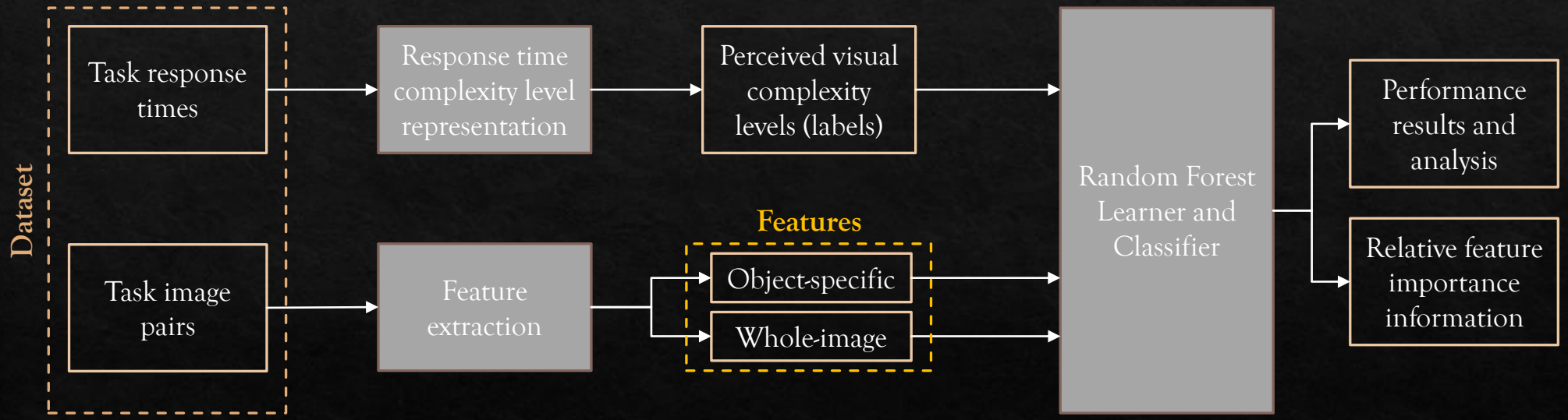
Approach

- Subjects' cognitive performance data was explored from NexSig's computerised cognitive testing studies:
  - Recognition Tests: 'Recognise which of the 3 images is different'



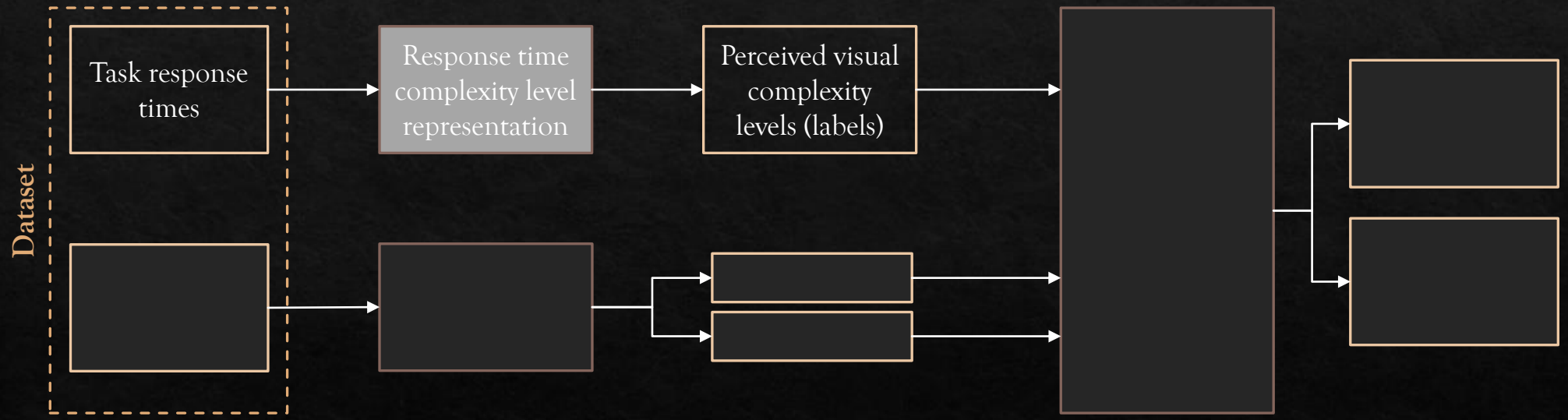
  - Data contained response times and correctness of answers

Algorithm Overview

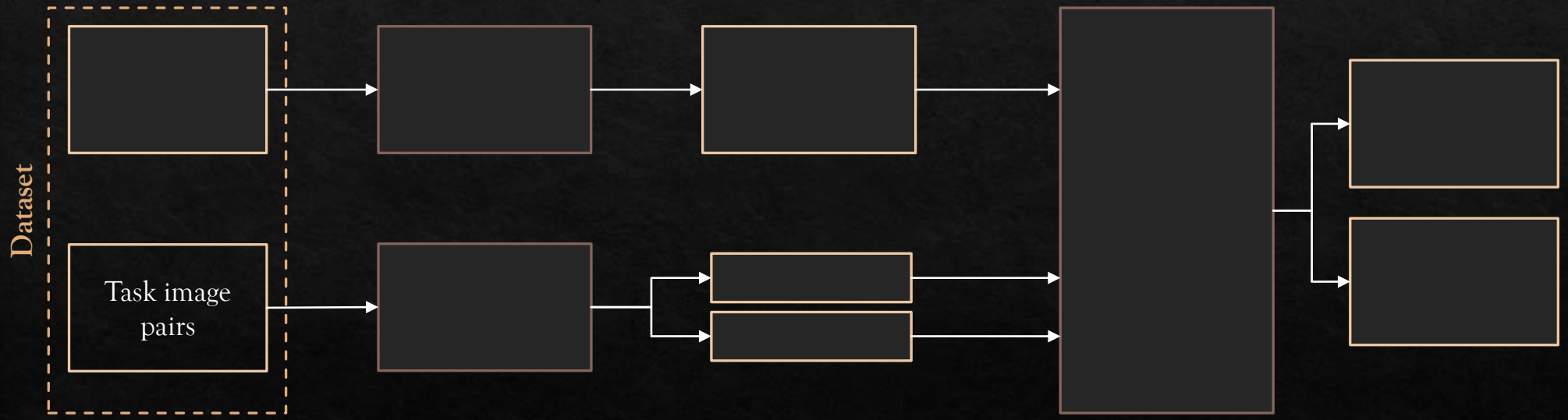


Algorithm: Response Times

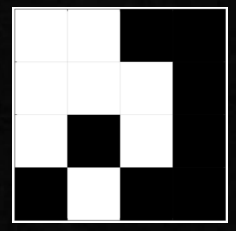
Response times used as indication of difficulty to distinguish between images in task
i.e. Slower response time → increased perceived difficulty → greater complexity level



Algorithm: Task Image Pairs



Unique image pairs from recognition tasks were extracted. Binary images were computationally encoded, scanning left to right, top to bottom, where black = 1, and white = 0.



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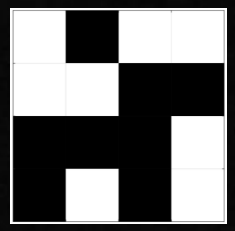

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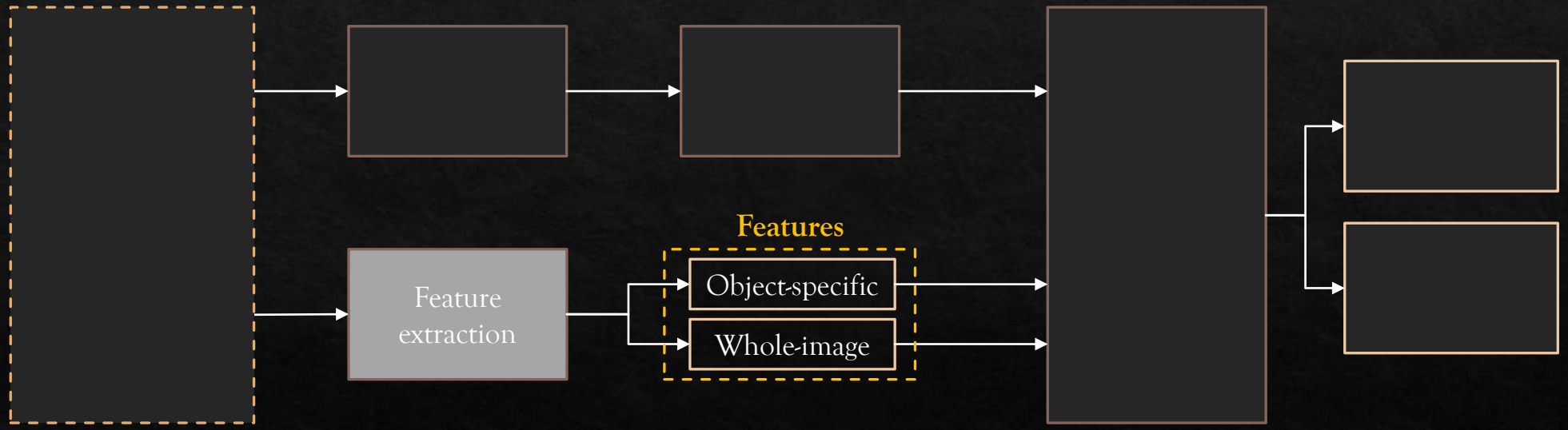
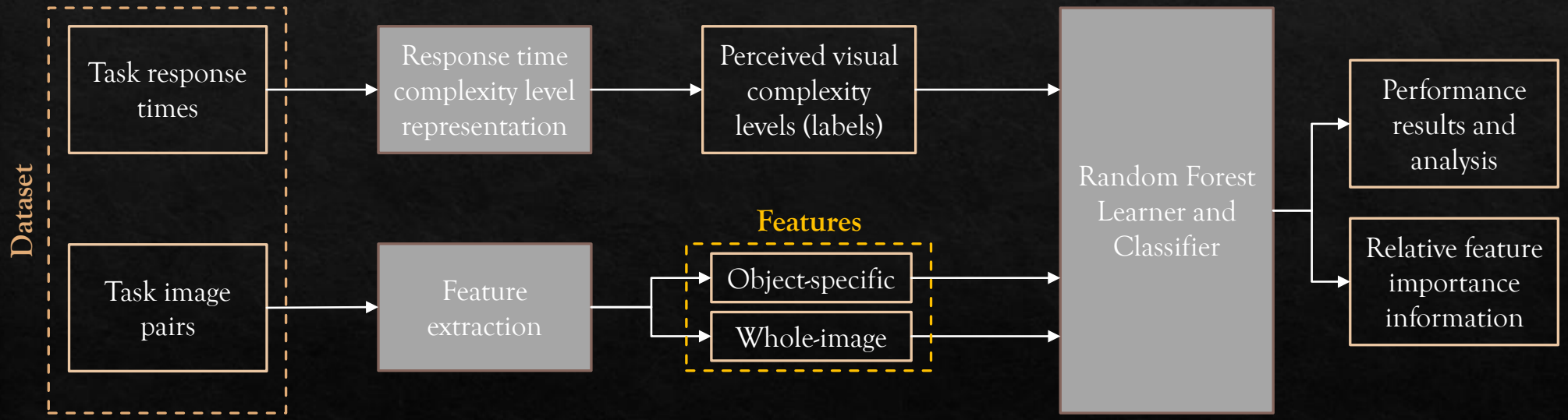
Algorithm: Feature Extraction



Algorithm: Feature Extraction

- Whole-image:
  - Overall object spacing within an image
  - Overall square-by-square comparison (relative)
  - Relaxed image symmetry within an image
  - Features from Gabor filters within an image
  - Fractal dimension features within an image
- Object-specific:
  - Number of objects
  - Object path lengths
  - Objects with similar angles (relative)
  - Objects at similar locations (relative)
  - Different object types present (relative)
  - Similar objects within an image
  - Similar objects in an image pair (relative)

Algorithm Overview

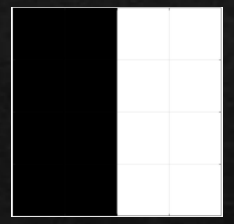
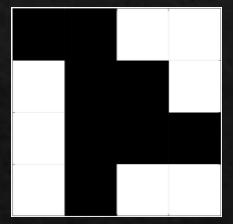
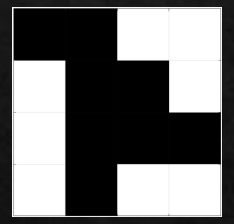
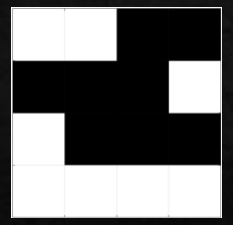
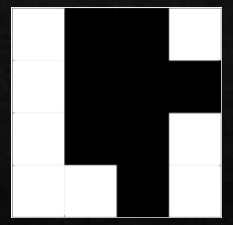
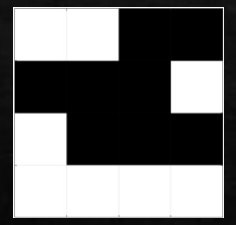
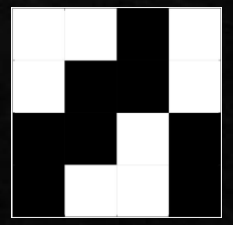
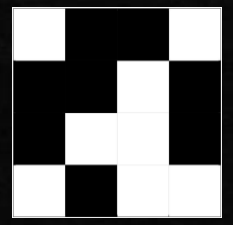
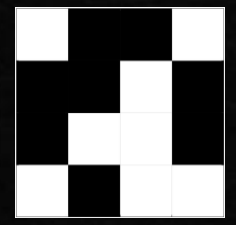


Results: Feature Importance Values

Whole-Image Features				Object-Specific Features			
Gabor filter std. dev	1.00	Fractal dimension std. dev.	0.56	Black adjacent path length/s	0.73	Number of black adjacent paths	0.41
Gabor filter sum	0.95	Black object spacing	0.53	Different black objects present	0.73	Number of white adjacent paths	0.39
Fractal dimension range	0.92	Black similar objects in an image pair	0.42	Similar black adjacent path location	0.61	Similar white diagonal path location	0.08
White object spacing	0.86	White similar objects in an image pair	0.26	Black similar objects within an image	0.57	Different white objects present	0.00
Relaxed symmetry	0.86	Direct squares comparison	0.23	White similar objects within an image	0.55		
Fractal dimension	0.76						

Results: Complexity Classifications

Examples of Recognition Tasks Correctly Labelled by the Algorithm Based on Subject Response Times

#	Image 1	Image 2	Image 3	Complexity Label
1				1 – Easy
2				2 – Medium
3				3 – Hard

Results: Key Takeaways

- Whole-image features have greater visual significance than object-specific features:
  - Individuals likely assess visual fields as a whole, making only loose visual partitions (as per Herman Witkin's psychological theories)
- Features that increase visual redundancy, such as image symmetry, could simplify the perceived complexity of images (as per Fred Attneave's theories on visual redundancy)
- The importance values of the various white-object-related features suggest that people perceive white pixels in a binary image as background space
- The greatest importance values of the mathematical features (Gabor filters and Fractal Dimensions) indicate a potential link between human visual perception and computational models of complexity

Conclusion

- Feature importance values corroborated psychological studies of human visual perception
- Findings suggest a potential link between human perception and computer-extracted features
- Further improvements can still be made to the algorithm by fine-tuning features and testing on a wider variety of visual stimuli

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Thank you

For any further questions or comments, please feel free to reach out to us at

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