

Biological Vision and Applications

Module 08-01: Applications



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Application areas

- We have reviewed 13 papers (2005 – 2019)
 - ▶ Visual Query Answering
 - ▶ Semantic Labeling
 - ▶ Content Adaptation
 - ▶ Content Recommendation
 - ▶ Surveillance
 - ▶ Photo Enhancement
 - ▶ Image Restoration
 - ▶ Scene Reconstruction
 - ▶ Human Robot Interaction

Common thread

Physical
world

Perception &
Cognition



Physical
world

Perception &
Cognition



- Transform visual signals as humans would perceive them
- Decide what is important – what should be processed and what should be ignored
- Context and human intention
- Fast and intuitive (hard real-time for some applications)

Guiding Principle 1

Recognize “Semantic Gap”

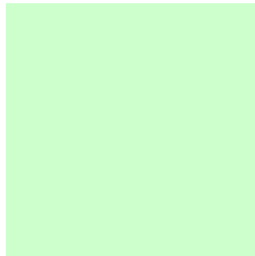
- Visual signals (features) and “semantics” do not correspond to each other
- Need for **in-context** abstraction of media features
 - ▶ Video summarization
 - ▶ Foreground-background separation
 - ▶ “Semantic” features (face, music, ...)
 - ▶ Painting Restoration
 - ▶ Cracks vs. lines
- The most difficult challenge in computer vision



Guiding principle 2

Contrast conveys information

- Principle of early vision
 - ▶ Contrasts: Color (R-G, B-Y) & illumination
 - ▶ Edge detection & perceptual grouping
 - ▶ Natural Scene Statistics
- Used in initial feature extraction / preprocessing
 - ▶ Crack detection (Painting, pipeline, railway track, ...)
 - ▶ Model of quality & aesthetics
 - ▶ Computational photography
- Convolution is a universal tool



Guiding principle 3

Contextual Semantics is conveyed through a very small fraction of the scene

- Decide what is important in a given context
 - ▶ Identification of important concepts in visual contents (robotics)
 - ▶ Fast & real-time processing (surveillance)
 - ▶ Semantic labeling and (visual) query answering
 - ▶ Video compression (storage & transmission)
 - ▶ “Signal-level fidelity” vs. “Semantic fidelity”
- Drastic reduction in information precessing
- Principle of attention is crucial for cognitive vision



Glas, et al. 2012



Cavallaro, et al. 2005

Guiding principle 4

Use contextual information

- Context disambiguates
- Context can be found elsewhere – not in the image alone
 - ▶ Caption (image / video)
 - ▶ Metadata (date/time, camera parameters, ...)
 - ▶ Markers in the environment
- Applications:
 - ▶ Semantic labelling & VQA
 - ▶ Robotics



He & Hu, 2019

Guiding principle 5

Principle of Inductive Generalization

- Apply knowledge from one task to another
 - ▶ Transfer learning
 - ▶ Few-shot or one-shot learning
 - ▶ Zero-shot learning
 - ▶ Multi-task learning
- Methods
 - ▶ Use of structured knowledge (machine learned)
 - ▶ Hierarchical Bayesian Model
- Applications:
 - ▶ Dealing with rare concepts / new queries
 - ▶ Cross-recommendation
 - ▶ Face region detection
 - ▶ Surveillance (railway track monitoring)



[More examples](#)

Other principles

- 6. Use of emergent knowledge
 - ▶ Where reliable models do not exist / difficult to codify
 - ▶ Examples: aesthetics, cracks in paintings
 - ▶ ML techniques (Clustering, Neural networks, ...)
- 7. Global workspace
 - ▶ Multiple processes working in parallel
 - ▶ Cognition to action (robotics)
- 8. Social networking
 - ▶ Learn from each other
 - ▶ Collaborative learning (robotics)
 - ▶ Imitation learning

Summary

Key takeaways from this course

- “Cognitive vision” encompassed all computer vision tasks
 - ▶ There are no specific applications of cognitive vision
 - ▶ Application of principles of biological vision in computer vision tasks
- There is no unified theory / framework for Cognitive Vision yet
 - ▶ Each topic covered in the course is an isolated dot
 - ▶ Cognitive Vision is like a vast ocean – We have explored some islands in the ocean

Your presentations, participations & reviews

Some common improvement suggestions

- Presentation
 - ▶ The key points (with respect to our class) need to be brought out clearly
 - ▶ Need to go beyond the paper (important methods used / critical thoughts)
 - ▶ Verbatim reading from the slides/notes makes a presentation drab
 - ▶ Need to generate enough interest in the audience – discussions
 - ▶ Time management – neither too short, not too long
- Participation & Review
 - ▶ Interactions required during/after presentation
 - ▶ Summary should be of optimal length – need to bring out key points crisply
 - ▶ Need professional assessment – dispersion of awarded marks
 - ▶ Specific comments (strengths/weaknesses)
 - ▶ Ratings should be adequately justified – especially very high and low ones
 - ▶ “Could not follow the presentation”, but awarded high scores

No quiz for module 08-01

End of Module 08-01