Attention transformers

E. Decencière

MINES ParisTech
PSL Research University
Center for Mathematical Morphology

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Transformers: a new revolution in deep learning?

- Transformers have brought a break-through in natural language processing
  - Bidirectional Encoder Representations from Transformers (BERT, by Google [Brown et al., 2020])
  - Generative Pre-trained Transformer 3 (GPT-3, by OpenAI [Devlin et al., 2019]): 175 billion parameters.
- They contribute to the development of new natural language processing applications (translation, voice assistants, etc.)
- Will they do the same in image analysis?

What are transformers?

A fist quick definition

A transformer is a neural network architecture module that explicitly allows the network to adaptively focus its attentions on certain regions of the data.

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How do we look at an image?

Figure: Ilya Repin, An Unexpected Visitor, 1884.

How do we look at an image?

Figure: Experiments on visual attention [Yarbus, 1967]

Tasks:

- Age of the characters?
- How long has the visitor been away?
- Memorize the objects in the scene.

Information used by human visual attention

- Bottom-up:
  - local features (orientation, intensity, junctions, colour, motion, etc.)
  - local features contrast
  - context
- Top-bottom: task related
- Construction of a single *saliency map*

Exploring the image

- Winner-takes all! We focus on the maximum of the saliency map.
- Inhibition of return: We explore the following maxima, at first avoiding those that have already been inspected

Why?

- Photoreceptor cells are expensive
- Processing power is limited
- Solution: concentrate the cells in a given region and use the gaze to optimize their use

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- The same arguments apply to artificial visual systems

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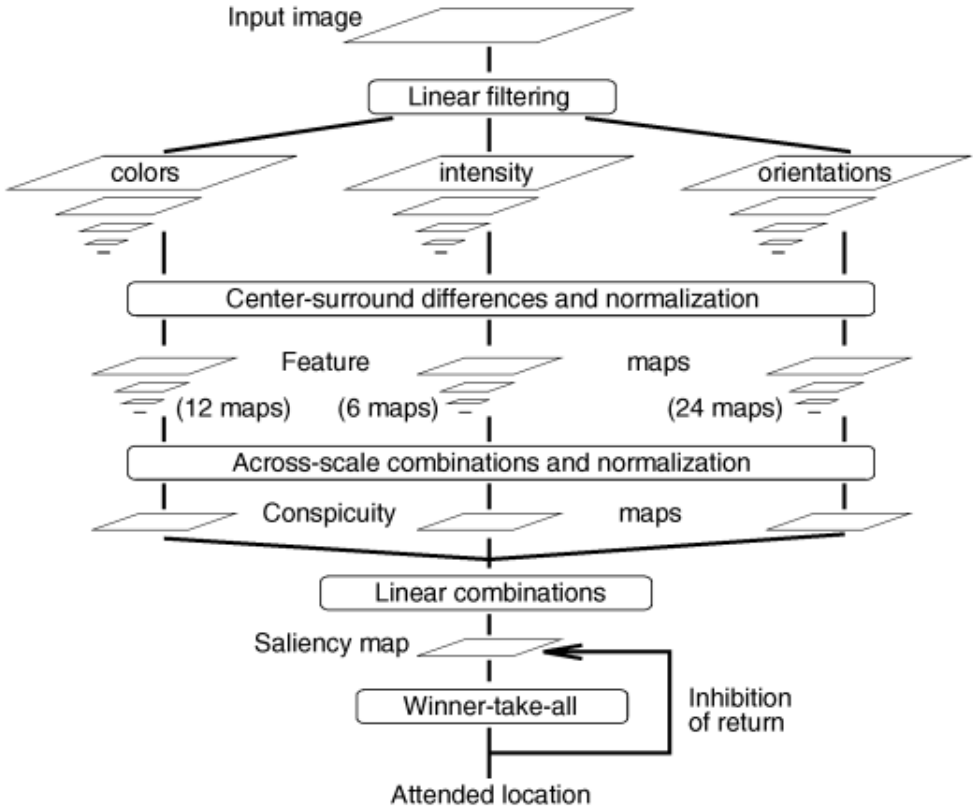
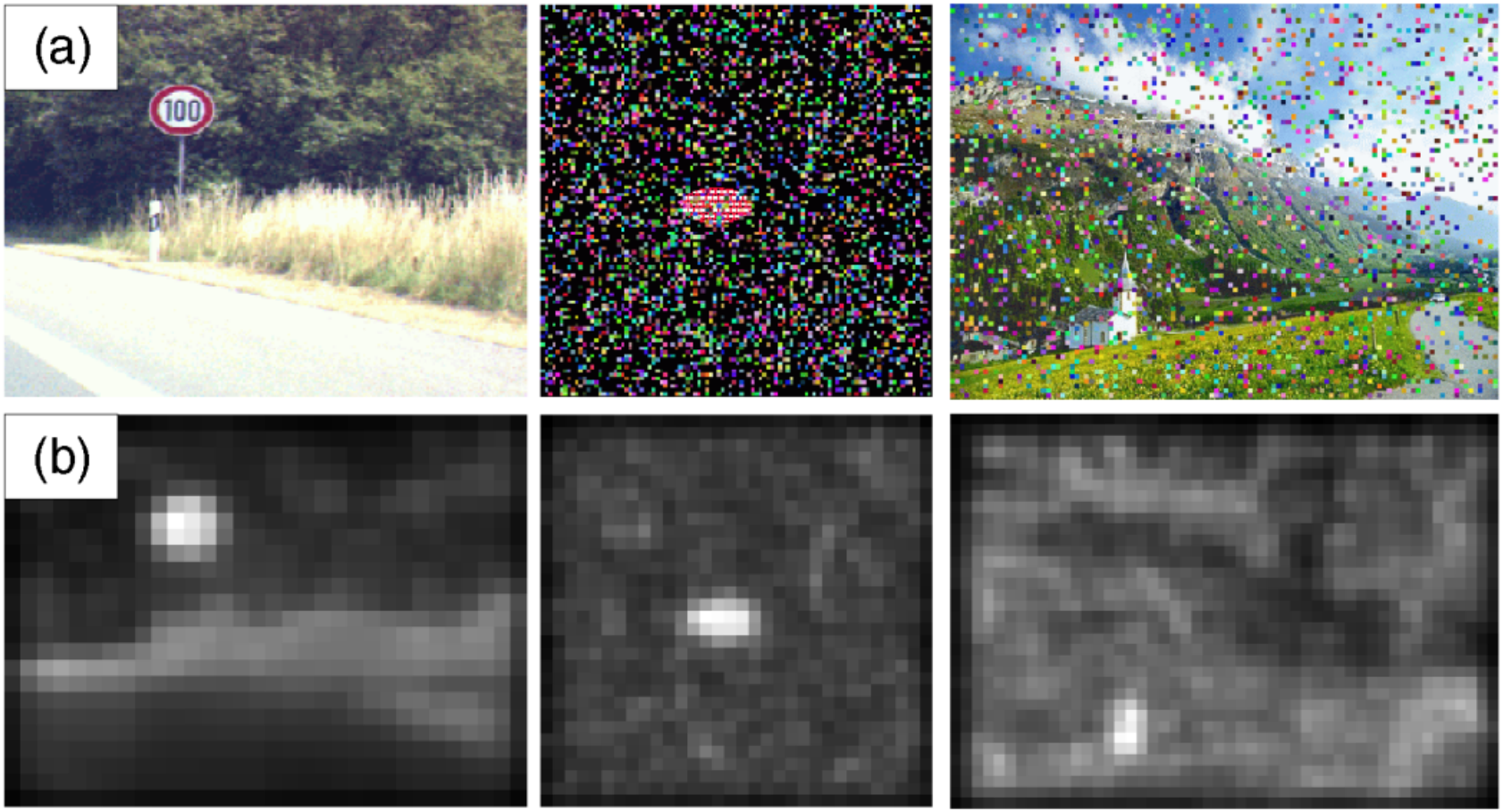
A classical bottom-up model

- Itti et al. [Itti et al., 1998] proposed a model inspired by the primate visual system.
- It only uses low-level information.



Examples [Itti et al., 1998]



Top-down attention models

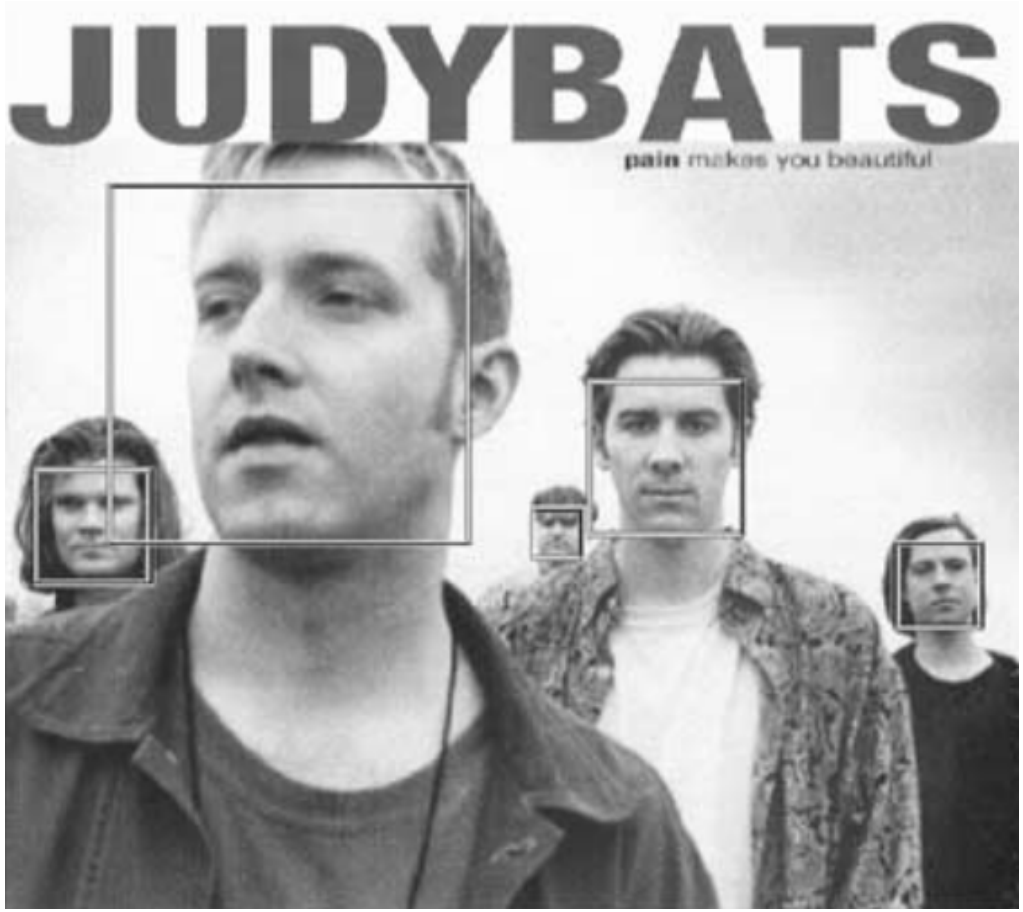
- These are task-dependant.
- Note that all detection methods can be considered as task-oriented attention methods

Example: Face detection with the Viola-Jones method [Viola and Jones, 2001]

- Define weak learners based on integrals on rectangles
- Select learners using AdaBoost
- Apply them in a hierarchical way

Image size: 24×24 pixels

Illustration [Viola and Jones, 2001]



Once attention is focused, the corresponding regions can be further analysed. Here, for identification purposes, for example.

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Historical land-marks

- Graph transformers: [Lecun et al., 1998]
- Transforming auto-encoders: [Hinton et al., 2011]

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