Analysis of texture: Practice

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Overview

Computer-based texture analysis (TA) is used to characterize the spatial distribution of signal intensity variations within local regions (2D or 3D) in an image, and can enable us to detect signal signatures and biology-related information that are otherwise imperceptible to the human eye. Although visual texture[1] is not a completely well-defined concept, image texture can be captured quantitatively using a broad range of statistical and mathematical measures. Early works by Tamura et al. (1978) attempted to develop computational definitions of basic textural features corresponding to human visual perception, and defined six basic textural properties: **coarseness**, **contrast**, **directionality**, **line-likeness**, **regularity**, and **roughness**. Since the seminal investigations in the 1970s and 1980s on texture perception in human vision by Bela Julesz at Bell Labs, there has been three main research tracks related to visual texture: (**i**) *psychophysical investigations* of visual texture perception, (**ii**) modeling, synthesis and mapping of texture in *computer graphics* for adding realism to computer-generated scenes, and (**iii**) **texture analysis** in *computer vision* and *pattern recognition*, including 'texture classification', 'texture segmentation', and 'shape from texture', with applications in remote sensing, industrial inspection, materials science, content-based image & video retrieval, and biological & medical imaging.

In medicine, magnetic resonance imaging is potentially one of the most exciting imaging technologies where TA can be applied[2]. This is because of the good soft tissue contrast offered by MRI along with extensive experimental control of the spatial resolution, signal to noise ratio, and contrast mechanism during an imaging experiment or patient examination. For these reasons, there have been reported an increasing number of MRI studies where TA is used to discriminate between patient groups, or detect architectural or pathophysiological differences between normal and abnormal tissue types or tissue conditions (cf. suggested reading).

Objectives

The objectives of this course on the practice of MRI texture analysis are: (**i**) recognize MR image analysis tasks and cases where TA can be valuable, (**ii**) give examples of successful TA applications in different organs and tissues, (**iii**) discuss the Pros and Cons for TA in MRI, (**iv**) track pointers to relevant TA software packages & programming tools and literature in the field.

The following topics will be covered in the course:

- ⊨ Why do TA?
- ⊨ What can we expect from TA?
- ⊨ How can we do TA?
- ⊨ Software for TA
- ⊨ Biomedical interpretation of TA
- ⊨ Challenges and pitfalls in TA
- ⊨ Examples of TA in different organs and tissues
- ⊨ The future of TA in MRI

[1] There are also other modalities or types of texture, e.g. *tactile texture*, *fabric texture*, *musical texture*, mouthfeel *food texture*, and spacetime *cosmic texture*. The concept of *visual texture* can further be characterized as the illusion of having physical texture or actual variations upon a surface.

[2] Interestingly, in the study of human texture recognition mechanisms functional MRI has been used, targeting the visual cortex [1, 2] - but TA was not incorporated in the fMRI analyses ...

Format

The course will be a combination of a slide presentation (LaTeX Beamer) and live demonstrations of texture analysis software packages (e.g. MaZda, MIPAV) and tools (e.g. MATLAB, Mathematica, Python). A web-link for downloading the course presentation including an extensive TA bibliography, and links to software tools and example data will also be provided.

Suggested reading:

Books on TA: [3] (presently the only textbook dealing with texture analysis in MRI), and [4, 5, 6, 7].

Classical papers: [8, 9, 10].

Review articles and book chapters: [11, 12, 13, 14, 15, 16, 17, 18, 19, 20].

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