Color regulation and stain separation utilizing hypercomplex image processing

Technology Offer

Ref. No.: 20-16

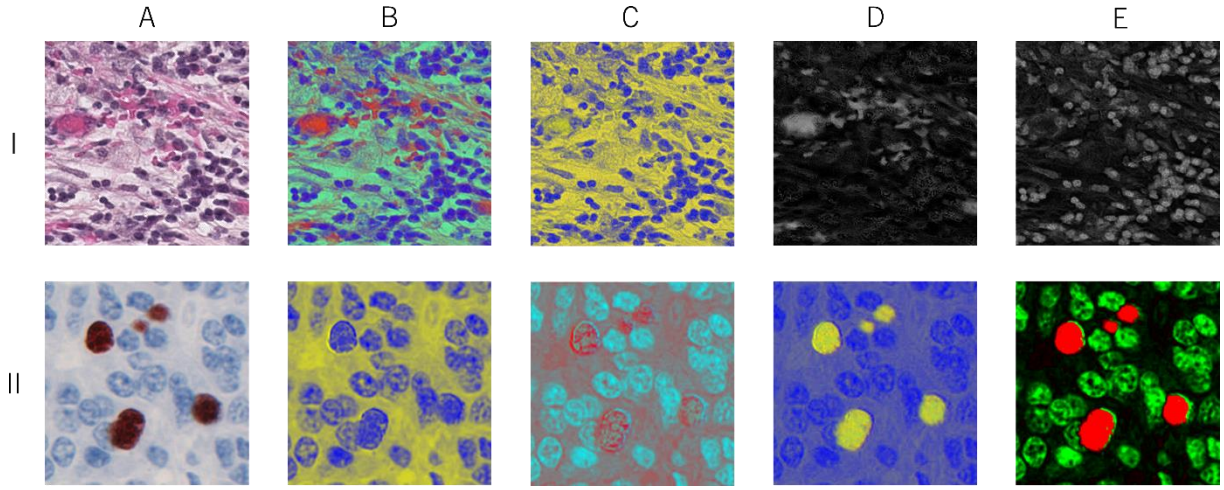

Fig. 1: Top row: (a) close-up image of an H&E stain, (b-c) two re-colorized renditions, and (d-e) two component stains (eosin and hematoxylin, respectively). Bottom row: (a) close-up image of a single immunostain, and (b-e) four modified representations (adapted from Valous *et al.*[1]).

Development stage
PoC

Seeking
Licensing

IP status
granted patent in US (US11501444B2)

Category
Image Analysis

Keywords
Images, color regulation, stain separation

Background

Across visual media and biomedicine, interpretations and decisions often depend on emphasizing and/or separating color appearance. In imagery and computer vision, stylistic re-colorizations unlock distinct and aesthetically relevant visuals. In pathomics, modified visual representations and staining component separations support subsequent qualitative and quantitative analyses.

The patented method (implementable as software module or integrated circuit) encodes color images as quaternion matrices and applies the 2D orthogonal planes split framework to generate robust, case-invariant color renditions and stain separations from selected or computed target colors. This enables more effective human-level assessments as well as reliable downstream quantifications.

Contact
ScienceValue Heidelberg GmbH
Berliner Straße 47 | 69120 Heidelberg | Germany
+49 (0)6221 - 567435 | www.sciencevalue-heidelberg.de/en
ScienceValue-Heidelberg@med.uni-heidelberg.de

Technology

The core IP covers a method for alternative color visualization and stain separation in natural and biomedical images by encoding each RGB pixel vector as a pure quaternion and decomposing the image into two orthogonal 2D components (q_+ and q_-) using the orthogonal planes split framework. The split is controlled by quaternions *f* and *g* that can be chosen manually or computed directly from the input image. The outputs are converted into triplets of real numbers forming R, G, and B channel matrices, which are then processed via normalization (0 to 1) or truncation (values <0 to 0, and >1 to 1) to enable modified renditions and stain separations. The patent also supports repeating the decomposition and processing for different *f* and *g* pairs, enabling multi-stage workflows (e.g. for double or triple stains). The method is pixel-based and therefore parallelizable on modern processors and graphics hardware, and can be deployed as a software module as well as an integrated circuit.

Benefits

- Rapid alternative color renditions and stain separations for natural and biomedical images.
- Flexible targeting: color renditions and stain separations can be defined manually or computed directly from the image.
- Non-data-driven and transparent: relies on deterministic arithmetic and matrix operations rather than training data.
- Practical stain handling: demonstrated on common pathology stain combinations with channel-level outputs.
- Deployable form factors: can run as standalone software or embedded in computational pipelines and devices.

Applications

- Natural image color regulation: fast re-colorization workflows for multimedia and graphics.
- Digital pathology: visualize and separate histological stains to support qualitative assessment and quantitative scoring.
- Pre-processing for computational pathology pipelines: stain isolation before feature extraction, machine learning, or quality control.
- Research microscopy and biomedical imaging: colorblind-friendly renditions and rapid exploration of stain patterns and tissue compartments.
- Further field imaging applications: general scientific research, aeronautics, deep sea and space exploration, and computational photography.

Publications

- US11501444B2: Valous N.A., Halama N., Zörnig I., Jäger D. Method, software module, and integrated circuit for color visualization and separation.
- [1] Valous N.A., Hitzer E., Duşe D., Moraleda R.R., Popp F., Suarez-Carmona M., Berthel A., Papageorgiou I., Fremd C., Rölle A., Westhoff C.C., Lenoir B., Halama N., Zörnig I., Jäger D. Computational workflows for natural and biomedical image processing based on hypercomplex algebras. *Patterns*, 6(11):101388, 2025. DOI: 10.1016/j.patter.2025.101388; PMID: 41328164; PMCID: PMC12664988.

Contact

ScienceValue Heidelberg GmbH
Berliner Straße 47 | 69120 Heidelberg | Germany
+49 (0)6221 - 567435 | www.sciencevalue-heidelberg.de/en
ScienceValue-Heidelberg@med.uni-heidelberg.de

SVH
ScienceValue Heidelberg