CHAOS THEORY AND MULTISCALE ENTROPY FOR GASTRIC CANCER DIAGNOSIS IN ENDOSCOPIC IMAGES

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Stomach & H. Pylori | Nurses | Immunology | Endoscopy | Digestive Oncology

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A multimodal AI model integrating chaos theory features, multiscale entropy, and deep learning achieved 91.5% weighted accuracy in classifying gastric NBI-ME images across six categories from inflammation to advanced cancer in a multicenter retrospective study of 6,850 images.

KEY POINTS

- The Fusion Model combining chaos/entropy features with deep learning reached macro-AUC 0.962 and weighted accuracy 91.5%, outperforming the deep learning-only model (macro-AUC 0.923, accuracy 87.9%) and the chaos/entropy-only model (macro-AUC 0.891, accuracy 83.2%).
- Sensitivity for flat early gastric cancer was 94.8% with the Fusion Model, significantly higher than the 85.3% achieved by the deep learning model alone.
- The dataset comprised 6,850 pathology-confirmed gastric NBI-ME images from five hospitals covering six classes: inflammation, intestinal metaplasia, low-grade intraepithelial neoplasia, high-grade intraepithelial neoplasia, early cancer, and advanced cancer.
- Chaos features included fractal dimension, Lyapunov exponent, and multiscale entropy extracted after transforming 2D images into 3D phase space trajectories using Hilbert curve scanning, revealing progressively increasing complexity from ordered inflammation patterns to chaotic advanced cancer configurations.
- Phase space analysis demonstrated that the fractal dimension, Lyapunov exponent, and multiscale entropy form a complementary chaos fingerprint enabling characterization of the phase transition from inflammation to carcinogenesis.
- The authors declare no competing interests and propose that future prospective validation studies combined with cellular and animal model experiments are needed to verify the phase transition spans multiple biological scales.

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