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PatchMoE-GC: Improving Gastric Tumour Microenvironment Classification with a Meta-Expert Routing Head

Hyogyu Ahn[1], Seungjin Lee[1], Suhyun Kim[2], nd Sangseon Lee[1,*]

[1]*Department of Artificial Intelligence, Inha University*
[2]*Department of Data Science, Inha University*
**Corresponding author: ss.lee@inha.ac.kr*

Gastric cancer is a major cause of cancer-related death worldwide. A key challenge is the heterogeneity of its tumour microenvironment (TME), which varies greatly both within and between tumours. This complexity has direct consequences for prognosis, immune response, and treatment outcomes. However, the development of accurate deep learning methods for tissue-microenvironment classification from histological images is hampered by (i) the difficulty of distinguishing between visually similar tissue classes (e.g. normal mucosa (NOR) vs stroma (STR) vs tumour epithelium (TUM)) and (ii) the tendency of straightforward classification heads to overfit or collapse when some classes are underrepresented. To address these challenges, we introduce PatchMoE-GC, a patch-level classifier for eight gastric TME classes, representing non-neoplastic components (adipose tissue, debris/necrosis, lymphocytes, normal mucosa, smooth muscle, stroma) and neoplastic epithelium (tumour). PatchMoE-GC builds on a pretrained histopathological patch encoder (UNI) and augments it with a lightweight mixture-of-experts (MoE) head: multiple simple MLP experts with a meta-expert acting as fallback, and a router that dynamically assigns each patch to top-k experts. To avoid imbalance or collapse onto a few experts, we introduce mild load-balancing together with a soft bias favouring class-matching experts. Training proceeds in three phases: (1) a warm-up phase where experts are trained with the backbone frozen; (2) a learning phase unfreezing the backbone partially and training router with class-balanced sampling and focal loss; (3) a refinement phase where the router is frozen and the expert heads are fine-tuned. On the HMU-GC-HE-30K dataset (~31,000 annotated patches from 300 slides), PatchMoE-GC reaches macro AUROC 96.16%, improving over the ViT (94%) baselines by 2.16 points, respectively; gains are most visible for lymphocyte and adipose patches and in separating challenging pairs such as normal, stroma, tumour. These results highlight that a small routing head with a meta-expert can substantially improve gastric TME classification without altering the backbone or relying on

ensembles.