

Glioma classification

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They are initially classified, based on their cell of origin, into [astrocytoma](#), [oligodendroglioma](#), or [ependymoma](#). Then, the establishment of the degree of malignancy according to the World Health Organization (WHO) classification criteria allows the organization of these tumors into grades ranging from I to IV.

The [World Health Organization Classification of Tumors of the Central Nervous System 2021](#), also known as WHO 5th edition, introduces substantial changes, especially within the [glioma](#) category, and separates adult-type and pediatric-type glial tumors into different categories for the first time. In addition, another category of glial tumors, "[Circumscribed Astrocytic Gliomas](#)" was also created. This group includes [pilocytic astrocytoma](#), [pleomorphic xanthoastrocytoma](#), [subependymal giant cell astrocytoma](#), [chordoid glioma](#), [astroblastoma](#), and the highly nebulous novel entity high-grade astrocytoma with piloid features ¹⁾.

With the advance of [genomics](#) research, there has been a new breakthrough in the molecular classification of [gliomas](#). [Glioblastoma](#) (WHO grade IV) could be subtyped to proneural, neural, classical, and mesenchymal according to the mRNA expression. [Low-grade gliomas](#) (WHO grade II and III) could be divided into 5 types using [1p/19q co-deletion](#), [isocitrate dehydrogenase \(IDH\) mutation](#), and [TERTp](#) (promotor region) mutation. In 2016, the markers such as IDH1 mutation were introduced into the diagnosis of gliomas. Genotype and phenotype were integrated to diagnose gliomas ²⁾.

Axial and nonaxial diffusivities, [anisotropy](#) indices in the normal-appearing [white matter](#) and their interhemispheric differences demonstrated microstructural differences between IDH and TERT mutations, with the potential for classification methods ³⁾.

Currently, classification of [neoplasms](#), especially regarding [gliomas](#), is established on molecular [mutations](#) in [isocitrate dehydrogenase \(IDH\) genes](#) and the presence of [1p/19q co-deletion](#) ⁴⁾

To propose a deep learning-based approach for the automated classification of glioma histopathology images. Two classification methods, the ensemble method based on 2 binary classifiers and the multiclass method using a single multiclass classifier, were implemented to classify glioma images into astrocytoma, oligodendroglioma, and glioblastoma, according to the 5th edition of the World Health Organization classification of central nervous system tumors, published in 2021.

Jose L et al. tested 2 different deep neural network architectures (VGG19 and ResNet50) and extensively validated the proposed approach based on The Cancer Genome Atlas data set (n = 700). We also studied the effects of stain normalization and data augmentation on the glioma classification task.

With the binary classifiers, the model could distinguish astrocytoma and oligodendroglioma (combined) from glioblastoma with an accuracy of 0.917 (area under the curve [AUC] = 0.976) and astrocytoma from oligodendroglioma (accuracy = 0.821, AUC score = 0.865). The multiclass method (accuracy = 0.861, AUC score = 0.961) outperformed the ensemble method (accuracy = 0.847, AUC = 0.933) with the best performance displayed by the ResNet50 architecture.

With the high performance of the model (>80%), the proposed method can assist pathologists and physicians to support examination and differential diagnosis of glioma histopathology images, with the aim to expedite personalized medical care ⁵⁾

WHO grade 1 glioma

[WHO grade 1 glioma](#)

WHO grade 2 glioma

[WHO grade 2 glioma](#)

WHO grade 3 glioma

[WHO grade 3 glioma](#)

WHO grade 4 glioma

[WHO grade 4 glioma](#)

Low-grade glioma

[Low-grade glioma](#)

High-grade glioma

[High-grade glioma](#)

Gliomas, glioneuronal tumors, and neuronal tumors

[Gliomas](#), [glioneuronal tumors](#), and [neuronal tumors](#):

[Adult-type diffuse gliomas](#)

[Astrocytoma IDH-mutant](#)

[Oligodendroglioma IDH-mutant and 1p/19q-codeleted](#)

[Glioblastoma IDH-wildtype](#)

[Pediatric-type diffuse low-grade gliomas](#)

[Diffuse astrocytoma MYB or MYBL1 altered](#)

[Angiocentric glioma](#)

[Polymorphous low-grade neuroepithelial tumor of the young](#)

[Diffuse low-grade glioma, MAPK pathway-altered](#)

[Pediatric-type diffuse high-grade gliomas](#)

[Diffuse midline glioma, H3 K27-altered](#)

[Diffuse hemispheric glioma, H3 G34-mutant](#)

[Diffuse pediatric-type high-grade glioma, H3-wildtype and IDH-wildtype](#)

[Infant-type hemispheric glioma](#)

[Circumscribed astrocytic gliomas](#)

[Pilocytic astrocytoma](#)

[High-grade astrocytoma with piloid features](#)

[Pleomorphic xanthoastrocytoma](#)

[Subependymal giant cell astrocytoma](#)

[Chordoid glioma](#)

[Astroblastoma MN1-altered](#)

[Glioneuronal and neuronal tumors](#)

[Ganglioglioma](#)

[Desmoplastic infantile ganglioglioma / desmoplastic infantile astrocytoma](#)

[Dysembryoplastic neuroepithelial tumor](#)

[Diffuse glioneuronal tumor with oligodendroglioma-like features and nuclear clusters](#)

[Papillary glioneuronal tumor](#)

[Rosette-forming glioneuronal tumor](#)

[Myxoid glioneuronal tumor](#)

[Diffuse leptomeningeal glioneuronal tumor](#)

[Gangliocytoma](#)

[Multinodular and vacuolating neuronal tumor](#)

[Dysplastic cerebellar gangliocytoma \(Lhermitte-Duclos disease\)](#)

[Central neurocytoma](#)

[Extraventricular neurocytoma](#)

[Cerebellar liponeurocytoma](#)

Glioma biology

The [tumors](#) classified as [gliomas](#) include a wide variety of histologies including the more common ([astrocytoma](#), [glioblastoma](#)), as well as the less common histologies ([oligodendroglioma](#), mixed [oligoastrocytoma](#), [pilocytic astrocytoma](#)). Recent efforts at the comprehensive genetic characterization of various primary brain tumor types have identified a number of common alterations and pathways common to multiple tumor types. Common pathways in glioma biology include growth factor receptor [tyrosine kinases](#) and their downstream signaling via the [Mitogen activated protein kinase](#) cascade or [PI3K](#) signaling, loss of [apoptosis](#) through [p53](#), cell cycle regulation, angiogenesis via [VEGF](#) signaling and invasion. However, in addition to these common general pathway alterations, a number of specific alterations have been identified in particular tumor types, and a number of these have direct therapeutic implications. These include mutations or fusions in the [BRAF](#) gene seen in pilocytic astrocytomas (and [gangliogliomas](#)). In oligodendrogliomas, mutations in [IDH1](#) and codeletion of chromosomes [1p/19q co-deletion](#) are associated with improved survival with upfront use of

combined chemotherapy and radiation, and these tumors also have unique mutations of [CIC](#) and [FUBP1](#) genes. [Low-grade gliomas](#) are increasingly seen to be divided into two groups based on [IDH](#) mutation status, with [astrocytomas](#) developing through IDH mutation followed by p53 mutation, while poor prognosis low-grade gliomas and primary glioblastomas (Glioblastomas) are characterized by [EGFR](#) amplification, loss of PTEN, and loss of cyclin-dependent kinase inhibitors. Glioblastomas can be further characterized based on gene expression and gene methylation patterns into three or four distinct subgroups. Prognostic markers in diffuse gliomas include IDH mutation, [1p19q co-deletion](#), and [MGMT](#) methylation, and MGMT is also a predictive marker in elderly patients with glioblastoma treated with [temozolomide](#) monotherapy ⁶⁾.

Glioma grade

see [Glioma grade](#).

Biomarkers

see [Glioma biomarker](#)

Localization

[Supratentorial glioma](#)

Infratentorial glioma.

Multifocal

see [Multiple gliomas](#)

see [Multifocal glioma](#).

see [Low-grade glioma](#) and [high-grade glioma](#).

Their various degrees of malignancy form the basis of the World Health Organisation (WHO) grading system:

[Pilocytic astrocytoma](#) is the most benign form of glioma (WHO Grade I), followed by a heterogeneous group of so-called “[Low-grade gliomas](#)” (WHO Grade II) that comprises oligodendroglioma, astrocytoma and oligoastrocytoma.

[Anaplastic glioma](#) (WHO Grade III) is a malignant and aggressive form of glioma but lacks the malignant characteristics of the [glioblastoma](#) (WHO IV), the most aggressive and most common glioma ⁷⁾.

Collective tissue banking, large-scale genomic, [transcriptomics](#) and methylomic expression profiling, and discoveries such as [isocitrate dehydrogenase](#) gene mutation and the C-phosphate-G island

methylation phenotype have improved glioma classification schemes.

Furthermore, the discovery of glioma stem cells has both enhanced and complicated our understanding. Gene signatures describing a proneural versus mesenchymal subtype within glioblastoma multiforme is reflected in both parental tumour as well as glioma stem cells and correlates with differential prognosis and response to radiation and chemotherapy ⁸⁾.

1)

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