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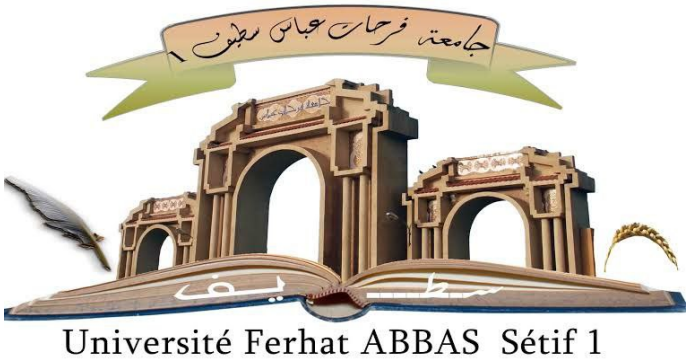

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A Clinical AI Platform for Cancer Research, Diagnosis, and Patient Care Using multi-modal Data

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Abstract :

Cancer research has advanced with biological databases enabling earlier tumor diagnosis and deeper disease insights. However, critical challenges persist, including high dimensionality, data heterogeneity, and the difficulty of integrating multiple modalities into coherent diagnostic frameworks. Machine learning offers promising solutions by automatically learning patterns from both structured clinical data and unstructured medical images, supporting accurate predictions and informed clinical decision-making.

This thesis presents MedIntel, a comprehensive multimodal platform for cancer diagnosis, prognosis, and patient care, integrating three complementary data modalities: medical imaging, clinical records, and multi-omics genomic data. Three AI models were developed: an imaging model based on ResNet50 with transfer learning for binary cancer classification; a clinical model using Cox Proportional Hazards for survival prediction; and a genomic model utilizing a Fusion Graph Neural Network integrating mRNA, miRNA, and protein expression data for early and late-stage lung cancer classification.

This work presents a fully integrated web platform that supports four user roles: administrators, doctors, researchers, and patients, each with tailored interfaces, where doctors perform AI-powered testing and patient management; researchers conduct literature searches and manage reports; patients access health information and communicate with providers. This framework improves diagnostic accuracy, supports analysis of complex multimodal datasets, and empowers patients with transparent access to predictions derived from their medical data.

Keywords: Artificial Intelligence, Machine Learning, Multimodal Learning, Cancer Diagnosis, Medical Imaging, Graph Neural Networks, Clinical Decision Support.

Résumé :

La recherche sur le cancer a progressé grâce aux bases de données biologiques, permettant un diagnostic tumoral plus précoce et une meilleure compréhension de la maladie. Cependant, des défis majeurs persistent, notamment la forte dimensionnalité des données, leur hétérogénéité et la difficulté d'intégrer de multiples modalités dans des cadres diagnostiques cohérents. L'apprentissage automatique offre des solutions prometteuses en apprenant automatiquement des modèles à partir de données cliniques structurées et d'images médicales non structurées, permettant des prédictions précises et une prise de décision clinique éclairée.

Cette thèse présente MedIntel, une plateforme multimodale complète pour le diagnostic, le pronostic et la prise en charge du cancer, intégrant trois modalités de données complémentaires: l'imagerie médicale, les dossiers cliniques et les données génomiques multi-omiques. Trois modèles d'IA ont été développés: un modèle d'imagerie basé sur ResNet50 avec apprentissage par transfert pour la classification binaire du cancer ; un modèle clinique utilisant le modèle de Cox à risques proportionnels pour la prédiction de la survie ; et un modèle génomique utilisant un réseau neuronal à graphes fusionnés intégrant les données d'expression d'ARNm, de miARN et de protéines pour la classification des cancers du poumon à un stade précoce et avancé. Ce travail présente une plateforme web entièrement intégrée qui prend en charge quatre rôles d'utilisateurs: administrateurs, médecins, chercheurs et patients, chacun disposant d'interfaces personnalisées. Les médecins y effectuent des tests assistés par l'IA et gèrent les dossiers des patients; les chercheurs y réalisent des recherches bibliographiques et gèrent les rapports; les patients y accèdent à leurs informations de santé et communiquent avec les professionnels de santé. Ce cadre améliore la précision du diagnostic, facilite l'analyse d'ensembles de données multimodaux complexes et offre aux patients un accès transparent aux prédictions issues de leurs données médicales.

Mots-clés: Intelligence artificielle, apprentissage automatique, apprentissage multimodal, diagnostic du cancer, imagerie médicale, réseaux neuronaux graphiques, aide à la décision clinique.

ملخص :

لقد شهدت أبحاث السرطان تقدماً ملحوظاً بفضل قواعد البيانات البيولوجية التي أتاحت تشخيص الأورام في مراحل مبكرة وفهم المرض بشكل أعمق. ومع ذلك، لا تزال هناك تحديات جوهرية، منها الأبعاد العالية، وتنوع البيانات، وصعوبة دمج طرائق متعددة في أطر تشخيصية متماسكة. يقدم التعلم الآلي حلولاً واعدة من خلال التعلم التلقائي للأنماط من كلٍ من البيانات السريرية المنظمة والصور الطبية غير المنظمة مما يدعم التنبؤات الدقيقة واتخاذ القرارات السريرية المستنيرة.تقدم هذه الأطروحة منصة ،MedIntel وهي منصة شاملة متعددة الوسائط لتشخيص السرطان والتنبؤ بمآله ورعاية المرضى، حيث تدمج ثلاث طرائق بيانات متكاملة وهي: التصوير الطبي، والسجلات السريرية، وبيانات الجينوم متعددة الأوميات. تم تطوير ثلاثة نماذج ذكاء اصطناعي وهي: نموذج تصوير قائم على ResNet50 مع التعلم بالنقل لتصنيف السرطان الثنائي؛ ونموذج سريري يستخدم نموذج كوكس للمخاطر النسبية للتنبؤ بالبقاء على قيد الحياة؛ ونموذج جينومي يستخدم شبكة عصبية بيانية هجينة يدمج بيانات التعبير الجيني لـ mRNA وmiRNA والبروتين لتصنيف سرطان الرئة في مراحله المبكرة والمتأخرة. يقدم هذا العمل منصة ويب متكاملة تدعم أربعة أدوار للمستخدمين: المسؤولون، والأطباء، والباحثون، والمرضى، ولكل دور واجهة مخصصة، حيث يُجري الأطباء اختبارات مدعومة بالذكاء الاصطناعي ويديرون شؤون المرضى؛ ويُجري الباحثون عمليات بحث في الأدبيات العلمية ويديرون التقارير؛ ويصل المرضى إلى المعلومات الصحية ويتواصلون مع مقدمي الرعاية الصحية. يُحسّن هذا الإطار دقة التشخيص، ويدعم تحليل مجموعات البيانات المعقدة متعددة الوسائط، ويُمكّن المرضى من الوصول الشفاف إلى التنبؤات المستمدة من بياناتهم الطبية.

الكلمات المفتاحية: الذكاء الاصطناعي، والتعلم الآلي، والتعلم متعدد الوسائط، تشخيص السرطان، والتصوير الطبي، والشبكات العصبية البيانية، ودعم القرار السريري

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