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系統論、代數生物學、人工智能：數學基礎與應用

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揭示生物實體之間的潛在關係（例如蛋白質-蛋白質相互作用 (PPI) 或疾病相似性預測任務）在生物信息學中仍然是一項挑戰。傳統方法使用手工特徵來計算不同實體之間的距離或相似度，這可能存在很大偏差，並且可能無法捕獲非線性依賴性。

然而，深度學習框架的出現允許開發複雜的模型來預測複雜的生物關係。 我們開發了 DeepTrio，一種使用掩碼多並行卷積神經網絡的基於序列的模型，用於 PPI 預測任務。DeepTrio 在各種指標方面明顯優於其他最先進 (SOTA) 方法，並且可以擴展以提供有關每個輸入神經元對預測結果的貢獻的更多見解。在疾病相似性預測問題上，我們提出了 CoGO，一種基於基因網絡和本體結構的對比學習框架，它使用圖深度學習模型結合了基因相互作用網絡和基因本體 (GO) 領域知識。我們提出了一個視圖間圖神經網絡來編碼網絡結構信息和一個交叉視圖對比損失來混合從基因網絡和 GO 圖學習的表示。 CoGO 在不同的評估指標上優於 SOTA，並提取可信的相似疾病，這些疾病與其他疾病相似性研究具有顯著可比性。

上述深度學習框架展示了深度學習在準確預測複雜生物過程方面的潛力，並為未來模型的發展提供了洞察力。 深度學習框架的使用有可能極大地促進我們對蛋白質-蛋白質相互作用和疾病關係的理解。

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PneumoScreener: AI based tool for automatic detection of anomalies from Chest XR and CT images

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In many hospital systems, Chest imaging is required for all patients when being admitted to the hospital. During pandemic Chest imaging was essential diagnostics tool of COVID-19 disease and in the decision making on hospitalisation and the treatment options, at various stages of the disease. Fast and accurate diagnostics of the COVID-19 is possible with chest X-ray (CXR) and computed tomography (CT) scan images. Our project, PneumoScreener, used AI, in particular deep learning approaches, to build an automated system that can be used in processing CXR and CT scans for early, or advanced signs of the COVID-19 pneumonia, or any other related pathology. We selected ResNet50 [1], EfficientNet B0 [2], EfficientNetv2 B02 [2], VGG162 [2] and our custom model. The chest X ray and CT scans from Serbian national data base (regular and COVID hospitals), combined with the datasets readily available from open access online databases were used for training, validation, and testing. We designed and implemented function PneumoScreenerPreprocessor, using C++ and OpenCV (with python used for automation and CMake for generating building files), for data pre-processing which were further used for the training of the neural networks. Software functionalities included data normalization, data augmentation (rotation, shift, flip), resizing and accuracy check. In addition, created software library PneumoScreener with routines for loading AI models, extracting features and performing predictions (inference) on datasets. Using this library, we have developed command-line interface (CLI) scripts: ModelSelection, FeatureExtractor and ImageClassifier for testing of algorithms for model selection, feature extraction and image classification. At the end, we selected deep learning model which we further optimized and used for extracting features and image classification. We defined and implemented several new AI algorithms for detecting: (1) if lungs are healthy or pneumonia is present, and (2) in case of pneumonia which type of pneumonia is present. In case of CXR (as input), model can detect four types of pneumonia: COVID, non-COVID-viral, Tuberculosis and non-Tuberculosis, other bacterial pneumonia. In case of CT slices, only COVID, non-COVID and Normal classes are available. In addition to detecting COVID-19 caused pneumonia and differentiating it from other viral and bacterial pneumonia types, the goal of our project was to determine the severity pneumonia. For the purposes of extraction of lung regions and lesions from CXR and CT slices, and calculating severity of pneumonia, we defined several algorithms which accept normalized (statistically) CXR / CT slice image, process it and output bitmaps with lungs and lesions masks. These segmentation models are developed as UNet models with EfficientNet and EfficientNetv2 as a backbone (we used B0 for testing). Finally, we designed and implemented several python scripts for automated testing of algorithms and applications, developed in previous phases, performed several iterations of testing. Also, we performed training of developed models on Serbian State Data Center (DGX supercomputer) infrastructure, tested trained models using developed scripts and compared training performances and prediction results with models trained on PC and other models on WWW. At the end, we analyzed the results and drew conclusions. After running test on all open access datasets (in-distribution test), we obtained cumulative accuracy of 97,1987 % and for CT models (in-distribution test) cumulative accuracy of 99,8676 %. These results are better from all models from COVID-Net [3] cited by 2567 other articles, large research initiative and most of models we found on WWW. After running on CXR dataset obtained from a Serbian COVID-19 hospital (out-of-distribution test), we obtained cumulative accuracy of 93,3993 %. We also developed an AI-powered clinical decision support system user interface (not subject of this article) and are working on its integration with a generic picture archiving and communication system (PACS) [4]. Furthermore, the results of our research and our PneumoScreener AI tool can be used as a fast-screening tool during future pandemics.

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PneumoScreener：基於 AI 的胸部 XR 和 CT 圖像異常自動檢測工具

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在許多醫院系統中，所有患者入院時都需要進行胸部成像。在大流行期間，胸部影像學是 COVID-19 疾病的重要診斷工具，也是疾病不同階段住院治療和治療方案決策的重要工具。 使用胸部 X 光 (CXR) 和計算機斷層掃描 (CT) 掃描圖像可以快速準確地診斷 COVID-19。我們的項目 PneumoScreener 使用 AI，特別是深度學習方法，構建了一個自動化系統，可用於處理 CXR 和 CT 掃描，以發現 COVID-19 肺炎或任何其他相關病理學的早期或晚期跡象。 我們選擇了 ResNet50 [1]、EfficientNet B0 [2]、EfficientNetv2 B02 [2]、VGG162 [2] 和我們的自定義模型。 來自塞爾維亞國家數據庫（正規醫院和 COVID 醫院）的胸部 X 光和 CT 掃描，結合開放訪問在線數據庫中現成的數據集，用於訓練、驗證和測試。我們設計並實現了函數 PneumoScreenerPreprocessor，使用 C++ 和 OpenCV（使用 python 實現自動化，使用 CMake 生成構建文件）進行數據預處理，進一步用於神經網絡的訓練。軟件功能包括數據規範化、數據擴充（旋轉、移位、翻轉）、調整大小和準確性檢查。此外，創建了軟件庫 PneumoScreener，其中包含用於加載 AI 模型、提取特徵和對數據集執行預測（推理）的例程。使用這個庫，我們開發了命令行界面 (CLI) 腳本：ModelSelection、FeatureExtractor 和 ImageClassifier，用於測試模型選擇、特徵提取和圖像分類的算法。最後，我們選擇了進一步優化的深度學習模型，用於提取特徵和圖像分類。我們定義並實施了幾種新的 AI 算法來檢測：1) 肺部是否健康或是否存在肺炎，以及 2) 如果是肺炎，則存在哪種類型的肺炎。 在 CXR（作為輸入）的情況下，模型可以檢測四種類型的肺炎：COVID、非 COVID-viral、結核病和非結核病、其他細菌性肺炎。 在 CT 切片的情況下，只有 COVID、非 COVID 和正常類可用。 除了檢測 COVID-19 引起的肺炎並將其與其他病毒性和細菌性肺炎類型區分開來，我們項目的目標是確定肺炎的嚴重程度。 為了從 CXR 和 CT 切片中提取肺部區域和病變，併計算肺炎的嚴重程度，我們定義了幾種算法，它們接受標準化（統計）CXR/CT 切片圖像，對其進行處理並輸出帶有肺部和病變掩膜的位圖。這些分割模型被開發為以 EfficientNet 和 EfficientNetv2 作為主幹的 UNet 模型（我們使用 B0 進行測試）。 最後，我們設計並實現了幾個 python 腳本，用於算法和應用程序的自動化測試，這些腳本是在前幾個階段開發的，進行了多次迭代測試。 此外，我們在塞爾維亞國家數據中心（DGX 超級計算機）基礎設施上對開發的模型進行了訓練，使用開發的腳本測試了訓練好的模型，並將訓練性能和預測結果與在 PC 上訓練的模型和 WWW 上的其他模型進行了比較。最後，我們對結果進行了分析並得出了結論。在對所有開放訪問數據集（分佈內測試）運行測試後，我們獲得了 97,1987% 的累積精度，CT 模型（分佈內測試）的累積精度為 99,8676%。 這些結果優於 COVID-Net [3] 的所有模型，這些模型被 2567 篇其他文章引用為大型研究計劃和我們在 WWW 上找到的大多數模型。 在從塞爾維亞 COVID-19 醫院（分佈外測試）獲得的 CXR 數據集上運行後，我們獲得了 93,3993% 的累積準確率。 我們還開發了一個 AI 驅動的臨床決策支持系統用戶界面（不是本文的主題），並致力於將其與通用圖片存檔和通信系統 (PACS) 集成 [4]。 此外，我們的研究結果和我們的 PneumoScreener AI 工具可用作未來大流行期間的快速篩查工具。

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Time and consciousness in intuitionism

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Brouwer's claims that time is a primordial intuition of consciousness has been considered in terms of the complex systems physics. The time continuum that is based upon a processual definition of real numbers concerns a skeletal category of such intuitionism which should be related to the measurement problem. A multiresolution hierarchy of the measurement process corresponds to the time operator that is a formalism of complex systems which was developed by the Brussels school of thermodynamics. The wavelet domain hidden Markov model that recapitulates statistical properties of the hierarchy has been proven tremendously useful in a variety of applications, including speech recognition and artificial intelligence. The model provides switching between outer and inner psychophysics, due to a change in representation which is the operational function of time. The inner psychophysics, which is a relation between sensation and neural activity, corresponds to the recognition of structural information that has been reflected by the increase of statistical complexity in the temporal domain. The optimal measurement corresponds to the most prominent increase that is an indicator of the system`s self-organization, which presents an evident link between time and consciousness.

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直覺主義中的時間和意識

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