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Advancing Forest Fire Prevention: Deep Reinforcement Learning for Effective Firebreak Placement

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Over the past decades, the increase in both frequency and intensity of large-scale wildfires due to climate change has emerged as a significant natural threat. The pressing need to design resilient landscapes capable of withstanding such disasters has become paramount, requiring the development of advanced decision-support tools. Existing methodologies, including Mixed Integer Programming, Stochastic Optimization, and Network Theory, have proven effective but are hindered by computational demands, limiting their applicability. In response to this challenge, we propose using artificial intelligence techniques, specifically Deep Reinforcement Learning, to address the complex problem of firebreak placement in the landscape. We employ value-function based approaches like Deep Q-Learning, Double Deep Q-Learning, and Dueling Double Deep Q-Learning. Utilizing the Cell2Fire fire spread simulator combined with Convolutional Neural Networks, we have successfully implemented a computational agent capable of learning firebreak locations within a forest environment, achieving good results. Furthermore, we incorporate a pre-training loop, initially teaching our agent to mimic a heuristic-based algorithm and observe that it consistently exceeds the performance of these solutions. Our findings underscore the immense potential of Deep Reinforcement Learning for operational research challenges, especially in fire prevention. Our approach demonstrates convergence with highly favorable results in problem instances as large as 40 x 40 cells, marking a significant milestone in applying Reinforcement Learning to this critical issue. To the best of our knowledge, this study represents a pioneering effort in using Reinforcement Learning to address the aforementioned problem, offering promising perspectives in fire prevention and landscape management

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Masked Image Modeling as a Framework for Self-Supervised Learning across Eye Movements

Robin Weiler, Matthias Brucklacher, Cyriel M. A. Pennartz, Sander M. Bohté

To make sense of their surroundings, intelligent systems must transform complex sensory inputs to structured codes that are reduced to task-relevant information such as object category. Biological agents achieve this in a largely autonomous manner, presumably via self-\allowbreak super-\allowbreak vised learning. Whereas previous attempts to model the underlying mechanisms were largely discriminative in nature, there is ample evidence that the brain employs a generative model of the world. Here, we propose that eye movements, in combination with the focused nature of primate vision, constitute a generative, self-supervised task of predicting and revealing visual information. We construct a proof-of-principle model starting from the framework of masked image modeling (MIM), a common approach in deep representation learning. To do so, we analyze how core components of MIM such as masking technique and data augmentation influence the formation of category-specific representations. This allows us not only to better understand the principles behind MIM, but to then reassemble a MIM more in line with the focused nature of biological perception. From a theoretical angle, we find that MIM disentangles neurons in latent space, a property that has been suggested to structure visual representations in primates, without explicit regulation. Together with previous findings of invariance learning, this highlights an interesting connection of MIM to latent regularization approaches for self-supervised learning. The source code is available under https://github.com/RobinWeiler/FocusMIM

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Text Prompt with Normality Guidance for Weakly Supervised Video Anomaly Detection

Zhiwei Yang, Jing Liu, Peng Wu

Weakly supervised video anomaly detection (WSVAD) is a challenging task. Generating fine-grained pseudo-labels based on weak-label and then self-training a classifier is currently a promising solution. However, since the existing methods use only RGB visual modality and the utilization of category text information is neglected, thus limiting the generation of more accurate pseudo-labels and affecting the performance of self-training. Inspired by the manual labeling process based on the event description, in this paper, we propose a novel pseudo-label generation and self-training framework based on Text Prompt with Normality Guidance (TPWNG) for WSVAD. Our idea is to transfer the rich language-visual knowledge of the contrastive language-image pre-training (CLIP) model for aligning the video event description text and corresponding video frames to generate pseudo-labels. Specifically, We first fine-tune the CLIP for domain adaptation by designing two ranking losses and a distributional inconsistency loss. Further, we propose a learnable text prompt mechanism with the assist of a normality visual prompt to further improve the matching accuracy of video event description text and video frames. Then, we design a pseudo-label generation module based on the normality guidance to infer reliable frame-level pseudo-labels. Finally, we introduce a temporal context self-adaptive learning module to learn the temporal dependencies of different video events more flexibly and accurately. Extensive experiments show that our method achieves state-of-the-art performance on two benchmark datasets, UCF-Crime and XD-Viole

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Generalized Contrastive Learning for Multi-Modal Retrieval and Ranking

Tianyu Zhu, Myong Chol Jung, Jesse Clark

Contrastive learning has gained widespread adoption for retrieval tasks due to its minimal requirement for manual annotations. However, popular contrastive frameworks typically learn from binary relevance, making them ineffective at incorporating direct fine-grained rankings. In this paper, we curate a large-scale dataset featuring detailed relevance scores for each query-document pair to facilitate future research and evaluation. Subsequently, we propose Generalized Contrastive Learning for Multi-Modal Retrieval and Ranking (GCL), which is designed to learn from fine-grained rankings beyond binary relevance scores. Our results show that GCL achieves a 94.5% increase in NDCG@10 for in-domain and 26.3 to 48.8% increases for cold-start evaluations, all relative to the CLIP baseline and involving ground truth rankings.

link: http://arxiv.org/abs/2404.08535v1

VertAttack: Taking advantage of Text Classifiers' horizontal vision

Jonathan Rusert

Text classification systems have continuously improved in performance over the years. However, nearly all current SOTA classifiers have a similar shortcoming, they process text in a horizontal manner. Vertically written words will not be recognized by a classifier. In contrast, humans are easily able to recognize and read words written both horizontally and vertically. Hence, a human adversary could write problematic words vertically and the meaning would still be preserved to other humans. We simulate such an attack, VertAttack. VertAttack identifies which words a classifier is reliant on and then rewrites those words vertically. We find that VertAttack is able to greatly drop the accuracy of 4 different transformer models on 5 datasets. For example, on the SST2 dataset, VertAttack is able to drop RoBERTa's accuracy from 94 to 13%. Furthermore, since VertAttack does not replace the word, meaning is easily preserved. We verify this via a human study and find that crowdworkers are able to correctly label 77% perturbed texts perturbed, compared to 81% of the original texts. We believe VertAttack offers a look into how humans might circumvent classifiers in the future and thus inspire a look into more robust algorithms.

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On the Robustness of Language Guidance for Low-Level Vision Tasks: Findings from Depth Estimation

Agneet Chatterjee, Tejas Gokhale, Chitta Baral, Yezhou Yang

Recent advances in monocular depth estimation have been made by incorporating natural language as additional guidance. Although yielding impressive results, the impact of the language prior, particularly in terms of generalization and robustness, remains unexplored. In this paper, we address this gap by quantifying the impact of this prior and introduce methods to benchmark its effectiveness across various settings. We generate "low-level" sentences that convey object-centric, three-dimensional spatial relationships, incorporate them as additional language priors and evaluate their downstream impact on depth estimation. Our key finding is that current language-guided depth estimators perform optimally only with scene-level descriptions and counter-intuitively fare worse with low level descriptions. Despite leveraging additional data, these methods are not robust to directed adversarial attacks and decline in performance with an increase in distribution shift. Finally, to provide a foundation for future research, we identify points of failures and offer insights to better understand these shortcomings. With an increasing number of methods using language for depth estimation, our findings highlight the opportunities and pitfalls that require careful consideration for effective deployment in real-world settings

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Memory Traces: Are Transformers Tulving Machines?

Jean-Marie Chauvet

Memory traces--changes in the memory system that result from the perception and encoding of an event--were measured in pioneering studies by Endel Tulving and Michael J. Watkins in 1975. These and further experiments informed the maturation of Tulving's memory model, from the GAPS (General Abstract Processing System} to the SPI (Serial-Parallel Independent) model. Having current top of the line LLMs revisit the original Tulving-Watkins tests may help in assessing whether foundation models completely instantiate or not this class of psychological models.

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Analyzing Decades-Long Environmental Changes in Namibia Using Archival Aerial Photography and Deep Learning

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This study explores object detection in historical aerial photographs of Namibia to identify long-term environmental changes. Specifically, we aim to identify key objects -- \textit{Waterholes}, \textit{Omuti homesteads}, and \textit{Big trees} -- around Oshikango in Namibia using sub-meter gray-scale aerial imagery from 1943 and 1972. In this work, we propose a workflow for analyzing historical aerial imagery using a deep semantic segmentation model on sparse hand-labels. To this end, we employ a number of strategies including class-weighting, pseudo-labeling and empirical p-value-based filtering to balance skewed and sparse representations of objects in the ground truth data. Results demonstrate the benefits of these different training strategies resulting in an average $F_1=0.661$ and $F_1=0.755$ over the three objects of interest for the 1943 and 1972 imagery, respectively. We also identified that the average size of Waterhole and Big trees increased while the average size of Omutis decreased between 1943 and 1972 reflecting some of the local effects of the massive post-Second World War economic, agricultural, demographic, and environmental changes. This work also highlights the untapped potential of historical aerial photographs in understanding long-term environmental changes beyond Namibia (and Africa). With the lack of adequate satellite technology in the past, archival aerial photography offers a great alternative to uncover decades-long environmental changes.

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RLHF Deciphered: A Critical Analysis of Reinforcement Learning from Human Feedback for LLMs

Shreyas Chaudhari, Pranjal Aggarwal, Vishvak Murahari, Tanmay Rajpurohit, Ashwin Kalyan, Karthik Narasimhan, Ameet Deshpande, Bruno Castro da Silva

State-of-the-art large language models (LLMs) have become indispensable tools for various tasks. However, training LLMs to serve as effective assistants for humans requires careful consideration. A promising approach is reinforcement learning from human feedback (RLHF), which leverages human feedback to update the model in accordance with human preferences and mitigate issues like toxicity and hallucinations. Yet, an understanding of RLHF for LLMs is largely entangled with initial design choices that popularized the method and current research focuses on augmenting those choices rather than fundamentally improving the framework. In this paper, we analyze RLHF through the lens of reinforcement learning principles to develop an understanding of its fundamentals, dedicating substantial focus to the core component of RLHF -- the reward model. Our study investigates modeling choices, caveats of function approximation, and their implications on RLHF training algorithms, highlighting the underlying assumptions made about the expressivity of reward. Our analysis improves the understanding of the role of reward models and methods for their training, concurrently revealing limitations of the current methodology. We characterize these limitations, including incorrect generalization, model misspecification, and the sparsity of feedback, along with their impact on the performance of a language model. The discussion and analysis are substantiated by a categorical review of current literature, serving as a reference for researchers and practitioners to understand the challenges of RLHF and build upon existing efforts.

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Scalability in Building Component Data Annotation: Enhancing Facade Material Classification with Synthetic Data

Josie Harrison, Alexander Hollberg, Yinan Yu

Computer vision models trained on Google Street View images can create material cadastres. However, current approaches need manually annotated datasets that are difficult to obtain and often have class imbalance. To address these challenges, this paper fine-tuned a Swin Transformer model on a synthetic dataset generated with DALL-E and compared the performance to a similar manually annotated dataset. Although manual annotation remains the gold standard, the synthetic dataset performance demonstrates a reasonable alternative. The findings will ease annotation needed to develop material cadastres, offering architects insights into opportunities for material reuse, thus contributing to the reduction of demolition waste.

link: http://arxiv.org/abs/2404.08557v1

MoPE: Mixture of Prefix Experts for Zero-Shot Dialogue State Tracking

Tianwen Tang, Tong Zhu, Haodong Liu, Yin Bai, Jia Cheng, Wenliang Chen

Zero-shot dialogue state tracking (DST) transfers knowledge to unseen domains, reducing the cost of annotating new datasets. Previous zero-shot DST models mainly suffer from domain transferring and partial prediction problems. To address these challenges, we propose Mixture of Prefix Experts (MoPE) to establish connections between similar slots in different domains, which strengthens the model transfer performance in unseen domains. Empirical results demonstrate that MoPE-DST achieves the joint goal accuracy of 57.13% on MultiWOZ2.1 and 55.40% on SGD.

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IDD-X: A Multi-View Dataset for Ego-relative Important Object Localization and Explanation in Dense and Unstructured Traffic

Chirag Parikh, Rohit Saluja, C. V. Jawahar, Ravi Kiran Sarvadevabhatla

Intelligent vehicle systems require a deep understanding of the interplay between road conditions, surrounding entities, and the ego vehicle's driving behavior for safe and efficient navigation. This is particularly critical in developing countries where traffic situations are often dense and unstructured with heterogeneous road occupants. Existing datasets, predominantly geared towards structured and sparse traffic scenarios, fall short of capturing the complexity of driving in such environments. To fill this gap, we present IDD-X, a large-scale dual-view driving video dataset. With 697K bounding boxes, 9K important object tracks, and 1-12 objects per video, IDD-X offers

comprehensive ego-relative annotations for multiple important road objects covering 10 categories and 19 explanation label categories. The dataset also incorporates rearview information to provide a more complete representation of the driving environment. We also introduce custom-designed deep networks aimed at multiple important object localization and per-object explanation prediction. Overall, our dataset and introduced prediction models form the foundation for studying how road conditions and surrounding entities affect driving behavior in complex traffic situations.

link: http://arxiv.org/abs/2404.08561v1

Mitigating Receiver Impact on Radio Frequency Fingerprint Identification via Domain Adaptation

Liu Yang, Qiang Li, Xiaoyang Ren, Yi Fang, Shafei Wang

Radio Frequency Fingerprint Identification (RFFI), which exploits non-ideal hardware-induced unique distortion resident in the transmit signals to identify an emitter, is emerging as a means to enhance the security of communication systems. Recently, machine learning has achieved great success in developing state-of-the-art RFFI models. However, few works consider cross-receiver RFFI problems, where the RFFI model is trained and deployed on different receivers. Due to altered receiver characteristics, direct deployment of RFFI model on a new receiver leads to significant performance degradation. To address this issue, we formulate the cross-receiver RFFI as a model adaptation problem, which adapts the trained model to unlabeled signals from a new receiver. We first develop a theoretical generalization error bound for the adaptation model. Motivated by the bound, we propose a novel method to solve the cross-receiver RFFI problem, which includes domain alignment and adaptive pseudo-labeling. The former aims at finding a feature space where both domains exhibit similar distributions, effectively reducing the domain discrepancy. Meanwhile, the latter employs a dynamic pseudo-labeling scheme to implicitly transfer the label information from the labeled receiver to the new receiver. Experimental results indicate that the proposed method can effectively mitigate the receiver impact and improve the cross-receiver RFFI performance.

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Enhancing Autonomous Vehicle Training with Language Model Integration and Critical Scenario Generation

Hanlin Tian, Kethan Reddy, Yuxiang Feng, Mohammed Quddus, Yiannis Demiris, Panagiotis Angeloudis

This paper introduces CRITICAL, a novel closed-loop framework for autonomous vehicle (AV) training and testing. CRITICAL stands out for its ability to generate diverse scenarios, focusing on critical driving situations that target specific learning and performance gaps identified in the Reinforcement Learning (RL) agent. The framework achieves this by integrating real-world traffic dynamics, driving behavior analysis, surrogate safety measures, and an optional Large Language Model (LLM) component. It is proven that the establishment of a closed feedback loop between the data generation pipeline and the training process can enhance the learning rate during training, elevate overall system performance, and augment safety resilience. Our evaluations, conducted using the Proximal Policy Optimization (PPO) and the HighwayEnv simulation environment, demonstrate noticeable performance improvements with the integration of critical case generation and LLM analysis, indicating CRITICAL's potential to improve the robustness of AV systems and streamline the generation of critical scenarios. This ultimately serves to hasten the development of AV agents, expand the general scope of RL training, and ameliorate validation efforts for AV safety.

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Small Models Are (Still) Effective Cross-Domain Argument Extractors

William Gantt, Aaron Steven White

Effective ontology transfer has been a major goal of recent work on event argument extraction (EAE). Two methods in particular -- question answering (QA) and template infilling (TI) -- have emerged as promising approaches to this problem. However, detailed explorations of these

techniques' ability to actually enable this transfer are lacking. In this work, we provide such a study, exploring zero-shot transfer using both techniques on six major EAE datasets at both the sentence and document levels. Further, we challenge the growing reliance on LLMs for zero-shot extraction, showing that vastly smaller models trained on an appropriate source ontology can yield zero-shot performance superior to that of GPT-3.5 or GPT-4.

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