Democratizing AI: A VPL-Based Prototype for Fostering Participation in Fair Decision-Making Processes

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ABSTRACT

Nowadays, Artificial Intelligence (AI) has permeated every aspect of our lives, with machine learning (ML) systems – grounded in complex algorithms and statistical models – significantly contributing to societal progress. Its pervasive nature across various industries is not just reshaping business practices by enhancing product, process, and decision-making capabilities [9], but also emphasizes the need for fair AI systems that are accessible to all. In academia, AI's role is equally transformative, compelling institutions to reassess and adapt their teaching and learning methodologies for effective integration of this technology[1]. Therefore, AI-based systems have the potential to revolutionize our ways of living, how we interact with one another, and our self-perception. Recommender systems, as an example, deploy algorithms to tailor search engine results based on user queries, thus influencing our consumption choices [10], public opinion, and perceptions of social reality[11]. These systems often base their filtering and ranking of information on opaque criteria, such as search history and demographic data, unveiling the need for explainable AI techniques to detect and mitigate potential biases, such as gender bias[8].

The rapid development of AI is accelerating our transition towards an algorithmic society, raising concerns about the complexity of algorithms and the concentration of AI knowledge in small groups[15]. Indeed, this complexity often concentrate control to skilled practitioners, deepening a dependency that might not align with societal ethical standards[13]. Bridging the gap between experts and the broader society is necessary, especially in sectors where responsible and trustworthy AI systems are involved in decision-making processes. By democratizing AI, we aim to provide socio-technical conditions that enable both experienced and inexperienced users to actively contribute to the design of ML-based systems, enhancing their understanding and trust. This participation not only supports diverse backgrounds in navigating our technology-driven society but also ensures that these systems are developed with a keen awareness of their societal and ethical implications[3].

Recent research highlights the need for a cultural shift, which can be facilitated through End-User Development (EUD). EUD equips individuals to move beyond merely consuming digital artefacts and systems, transforming them into active contributors to problem-solving processes[7] such as in adapting smart environments[4]. In the realm of trustworthy AI, engaging inexperienced users in the design process of ML-based systems has the potential to positively impact the fairness of software across various domains[12]. Research in Human-Centered AI (HCAI) is revealing new methods for involving users with limited experience via intuitive visual interfaces [14]. For example, in the educational sector, Visual Programming Languages (VPLs) and no-code platforms such as Scratch[2] are providing accessible experiences by streamlining computational tasks. Besides, market trends have highlighted the emergence of various VPL-based tools for data mining and analytics, each offering entry points into ML and data science for users with different skill levels. However, these tools often face limitations in terms of customizability, open-source access, and the integration of interpretability techniques, making it challenging for users to fully engage with ML processes and understand decision-making mechanisms.

Addressing this gap, our research introduces the PyFlowML prototype, developed in an open-source, flow-based environment[1] to combine customizability with simplified ML processes for domain specialists. This study is driven by the research question: *Can VPL-based frameworks foster the participation of practitioners, regardless of their experience level, in the design of fair ML-based systems?*

PyFlowML prototype. PyFlow[2] is a versatile Python Qt visual scripting framework designed to simplify the creation of graphical user interfaces (GUIs) through the utilization of visual programming techniques. In PyFlowML package, nodes are categorized into four main categories: Data Load, Data Visualization, Data Classification, and Explainable AI. The Data Load category allows importing numerical and textual data from various sources, including external files and libraries like scikit-learn. The Data Visualization nodes enable users to display outcomes in tables and plots. Data Classification category encompasses a variety of supervised learning models (e.g., Deep Neural Networks, K-Nearest Neighbors, Gradient Boosting, Random Forests, and Support Vector Machines) and unsupervised learning models like K-means for clustering. Lastly, the Explainable AI category incorporates techniques like SHAP (SHapley Additive exPlanations) to aid users interpret decision-making processes and understand feature relationships.

Methodology. In this study, we conducted an expert review, blending cognitive walkthroughs with heuristic evaluations[6]. This method enabled us to explore how users interact with PyFlowML,

womENcourage, June 26-28, 2024, Madrid, Spain

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM…$15.00
https://doi.org/10.1007/978-3-031-35681-0_10

[1] Flow-based languages, represented by directed graphs, leverage the data flow paradigm where nodes represent functions and arcs depict the data pathways between them[5].
[2] https://pyflow.readthedocs.io/en/latest/intro.html

with a focus on insight generation over definitive findings. Our exploratory approach also incorporated think-aloud protocols and a post-test survey based on the System Usability Scale (SUS) to collect user feedback. We engaged nine experts with expertise in VPLs, programming, and ML for this review. These experts, acting as simulated users, followed a predefined template to address a fairness task within the recruitment domain. The task involved: loading the "IBM HR Analytics Employee Attrition & Performance" dataset[3], applying a ML model, and computing SHAP values. Throughout this process, experts were prompted with questions about the outputs at each stage, such as the accuracy of the classifier, the features importance, and the presence of sensitive attributes in the data. The sessions were recorded to capture verbal feedback and observations, providing insight into the experts' awareness of the potential impacts, both positive and negative, of the ML-based prototypes they designed.

Discussion. In the post-hoc analysis, we examined the findings from the think-aloud protocol and heuristic evaluation. These methods yielded insightful feedback on the tool's implementation and showed a positive outcome in the overall System Usability Scale (SUS) score. Using PyFlowML, the experts developed their ML-based prototypes and, through Shapley value analysis, identified eleven potential sensitive attributes – such as distance from home, relationship satisfaction, and overtime hours – in addition to age, gender, and marital status. To delve deeper into fairness analysis, they proposed several strategies, including rerunning the pipeline without these features, analyzing correlations among them (e.g., marital status and distance from home, or age and overtime hours), or using different classifiers for the same task.

Conclusion. The advancement of AI is leading society towards an algorithmic future, raising concerns about complex algorithms and the centralization of AI knowledge among a small group of specialists. This scenario risks consolidating technological control among professionals, which could potentially conflict with societal ethical standards. Our research introduces PyFlowML, a flow-based programming prototype designed to democratize the development of trustworthy ML-based systems. Through an expert review using cognitive walkthroughs and heuristic evaluations, we assessed PyFlowML's ability to foster user participation in ML-based system design. Experts acting as simulated users conducted fairness tasks in recruitment domain using PyFlowML, uncovering areas for prototype improvements. Preliminary findings suggest that PyFlowML can encourage user participation in detecting potential biases and formulating strategies for their mitigation. However, they also highlight the need to lessen the cognitive load for users, such as in complex tasks like interpreting SHAP values to better understand the impact of features on ML-based system predictions. Future work will include broader expert evaluations, comparative tool analyses, and the use of the NASA Task Load Index to gain deeper insights into cognitive load, aiming to refine user experience further.

CCS CONCEPTS

• **Human-centered computing** → *Graphical user interfaces.*

[3]https://www.kaggle.com/datasets/pavansubhasht/ibm-hr-analytics-attrition-dataset/code

KEYWORDS

visual programming language, participation, AI democratization, machine learning, fairness

ACM Reference Format:

Serena Versino, Tommaso Turchi, and Alessio Malizia. 2018. Democratizing AI: A VPL-Based Prototype for Fostering Participation in Fair Decision-Making Processes. In *Proceedings of ACM Celebration of Women in Computing (womENcourage).* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1007/978-3-031-35681-0_10

ACKNOWLEDGMENTS

Research partly funded by PNRR - M4C2 - Investimento 1.3, Partenariato Esteso PE00000013 - "FAIR - Future Artificial Intelligence Research" - Spoke 1 "Human- centered AI", funded by the European Commission under the NextGeneration EU programme.

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Received April 17, 2024