



## PieVal: Web-based, Secure, Distributed, Fast text data label capture

UC Davis Health

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## The Challenge

83% of useful biomedical data locked in unstructured notes containing an unknown amount of protected health information. Providing access to and analysis of this data is both a legal and technical challenge critical to overcome in becoming a learning healthcare system. At UC Davis there are over 300 million clinical notes which requiring special technical competencies to manage movement, storage, and analysis using technologies not typically found at health centers. Legally, these data are challenging due their uniquely personal nature. A large parallel focus is the reduction of potential patient harm through advanced text de-identification processes. Natural Language Processing (NLP) has been advanced and commoditized by other domains with less ambiguity and legal control; our challenge is to leverage contextual and localized adaptations to it as an effective tool in the clinical domain. Localization is accomplished by re-creating successful NLP models and training approaches on clinical data. While some of this can be done via self-supervision, much of it will require human annotated gold standard labels provided in the context of the clinical domain. Text annotation tooling does exist in the community in both commercial and open-source forms, but it is either too slow or too insecure to be practical in the healthcare domain. The need for specialized clinical knowledge for training of data sets is required for high quality, meaningful annotations. This same specialized knowledge has conflicting demands on time treating patients, requiring novel and efficient approaches to extract that expertise in an agile fashion. Furthermore, the currently available tools and approaches are too insecure in general, due to their genesis in non-clinical domains. To account for deployment in health settings we must prioritize security principles given that clinical note data is full of PHI and PII.

## The Solution

We built PieVal – a combination of ‘Pie’ for Python, and ‘Val’ given its focus on data validation exercises – as a web-based, secure, high-throughput text label capture tool. It is designed to integrate cleanly into a “human in the loop” continuous improvement workflow from initial model

training to ongoing quality assurance monitoring. With the unavoidable reliance on clinically trained humans in the loop, our focus was in optimizing this key step. Selecting the best solutions for these specific stakeholders and domain constraints allowed us to choose the technologies and shape the user experience in such a way that annotation time was minimized, high-quality knowledge datasets could be produced, and stakeholders gained value from time contributions.

Technically, PieVal is a Python Flask web application that is easily deployed as web application behind a load-balancing proxy server, such as Apache. Authentication is provided by an open-source platform known as KeyCloak that integrates well with Shibboleth, and authorization of users and data access is managed within the app and configurable by project. A data workflow is described in Figure 1.

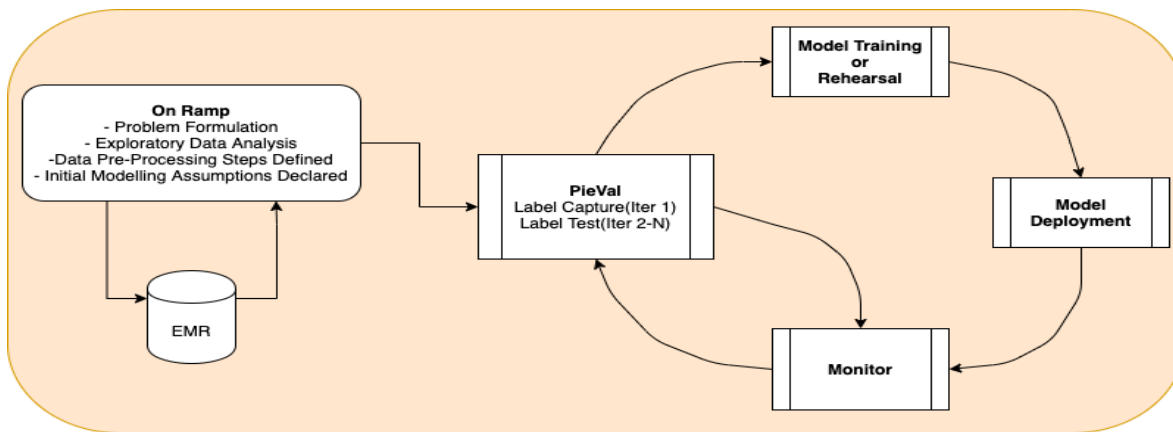


Figure 1 – PieVal workflow

## PieVal Features

PieVal provides a rapid, efficient, collaborative and scalable approach to expert community labeling and annotation of clinical notes. It supports multiple users in independent or collaborative tasks, and is accessible in web or mobile forms. It has a range of functions oriented around adoption and efficiency for the end-user.

*Multi-Project support* –PieVal can be configured once and used in many complementary projects. All access and authorization is scoped to maintain user access only to authorized projects (Figure 2).

Project	Your Status (% complete)	Description	Data Type	Mode
<a href="#">kappa_lambda_demo</a>	20.0	DEMO PROJECT: Determining if monotypic/clonal plasma cell populations exist	text	binary
<a href="#">cncr_hist_mc_demo</a>	0.0	DEMO PROJECT: Classifying cancer histology from pathology report text	text	multiclass
<a href="#">movie_reviews_demo</a>	10.0	DEMO PROJECT: Classifying sentiment from movie reviews	text	multiclass
<a href="#">image_demo</a>	0.0	DEMO PROJECT: Classifying image contents	image	binary

Figure 2 – Project Index

*Project Leaderboard* – PieVal incentivises friendly competition between annotators on the same project. In addition to sharing triangulation on labelling in complex domains between experts, it

can be used to offer rewards to top N annotators within a defined period of time (daily, weekly) – see Figure 3.

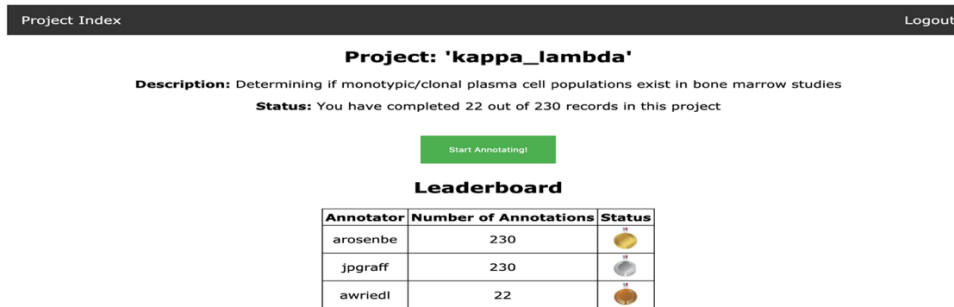


Figure 3 – Project leaderboard; used to run friendly competitions between the annotators

*Persistent User Interface* – The decision-making labeling schema presents a consistent set of options that encourage rapid decision making for any similar annotation experience. This prompts the reuse of the environment with limited orientation or training (figure 4). To handle multi-class ‘Disagree’, the user is interrupted and asked for correct label from a dropdown. Advanced type-ahead enables rapidly finding the correct label (figure 5).

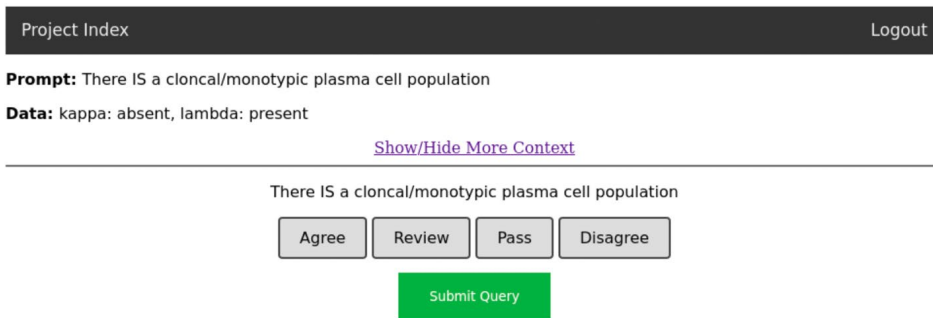


Figure 4 – Persistent UI and response options

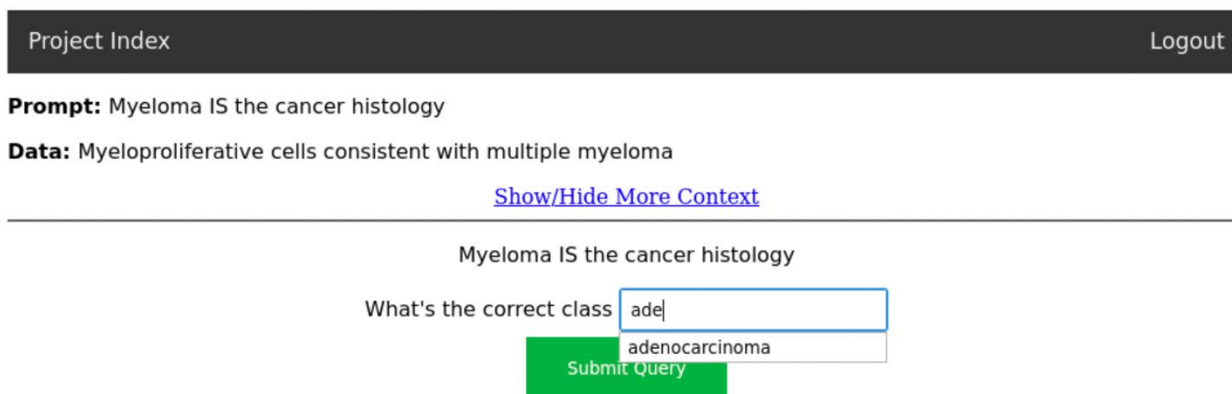


Figure 5 – Multiclass correct label selection

*Enriched text presented by default* - A typical clinical note will have sections such as Impression, Assessment and Plan, Clinical Findings, etc... Frequently, an NLP effort will focus on one or several of these sections rather than computing on the entire note. It is common to enrich the corpus by removing the other, suspected unhelpful, sections. PieVal can be configured to

display only the enriched text by default, limiting the amount of off target text the reviewer must consider which speeds the process considerably. However, sometimes enrichment strategies are wrong. PieVal offers a link that will present the full body of the original note when the enriched text is ambiguous. Viewing of the original text is tracked, allowing the study team to measure how often it was required to provide an annotation.

Project Index Logout

**Prompt:** There IS a clonal/monotypic plasma cell population

**Data:** kappa: absent, lambda: present

**Data ext:** BONE MARROW, RIGHT POSTERIOR ILIAC CREST, ASPIRATE SMEAR, TOUCH PREP, CLOT SECTION, CORE BIOPSY, AND PERIPHERAL BLOOD SMEAR: HYPOCELLULAR MARROW (~20%) WITH TRILINEAL HEMATOPOIESIS BLASTS ARE NOT INCREASED NO MORPHOLOGIC OR IMMUNOPHENOTYPIC EVIDENCE FOR MARROW INVOLVEMENT BY B-CELL LYMPHOMA DECREASED IRON STORES (1+/6+) WITH NO RING SIDEROBLASTS FOCAL RETICULIN FIBROSIS (1+/4+) PERIPHERAL BLOOD SMEAR SHOWING PANCYTOPENIA AND NO CIRCULATING BLASTS FLOW CYTOMETRY: NO MONOTYPIC B-CELL POPULATION BLASTS ARE NOT INCREASED And kappa restricted plasma sheets. COMMENT: The patient is a 34 year old famous mouse with a history of making childrens movies. The bone marrow is normocellular with trilineal hematopoiesis and increase in blasts. A few lymphoid aggregates are noted, but they appear small. IHC staining supports the presence of reactive lymphoid aggregates. ASPIRATE SMEAR / TOUCH PREP: Quality: Adequate. Cellularity: Cellular. Myeloid lineage: Adequate in number with appropriate maturation. Erythroid lineage: Adequate in number with normoblastic maturation. Megakaryocytes: Adequate in number and unremarkable in morphology. Other: Blasts are not increased. No lymphoid aggregates seen. See Differential section for detailed differential count. CORE BIOPSY: Quality: Adequate. Bone / soft tissue: Normal. Cellularity: Hypocellular at approximately 20% cellularity overall. INTERPRETATION: The above immunostains support the above diagnostic impression.

[Show/Hide More Context](#)

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There IS a clonal/monotypic plasma cell population

Agree Review Pass Disagree

Submit Query

Figure 6 – Enriched data and Full data presented after user requests ‘more context’

## The Impact

To date, 17 projects totaling over 1300 annotations have been captured with an average annotation time of 19 seconds [21,23 95%CI] per clinical document. At sub-20 second mean annotation times we have found the engagement for specialized personnel supplying human annotations minimized to an acceptable level – by the personnel themselves. PieVal offers good signal capture and has contributed to multiple successful models moved into production. Finally, it’s fun - our users have reported it’s nice to use and enjoy the leaderboards friendly competition among annotators. It has been so successful on text; we are extending it to support image and table data annotations.

## The Timeline

The need for a fast annotation capture tool was being discussed in Fall of 2019. An early proof of concept in the RShiny framework was available in November of 2019. The conceptual pilot was popular but the RShiny framework was not up to the task of production use on the large scale corpuses in question. The first code commit for PieVal was January 15<sup>th</sup>, 2020. The first non-test project captured its first annotation on January 30<sup>th</sup>, 2020. In total, PieVal went from idea to production implementation in approximately 6 months, with actual app development occurring in just 2 weeks.

## The Future

We see PieVal as a contribution to instrumenting the enterprise for linking critical, unique and costly domain expertise to characterizing the vast range of clinical notes in secure and efficient ways. We seek to offer the PieVal framework as a research informatics framework for adoption to other the UC’s and eventually release it open source to contribute new approaches for creating expert-defined data annotation workflows.