

Problem Statement and Goals

SFWRENG 4G06 - Capstone Design Process

Team 17, DomainX

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Table 1: Revision History

Date	Developer(s)	Change
September 20, 2025	Awurama Nyarko, Fei Xie Ghena Hatoum Haniye Hamidizadeh	Created first draft of document
September 28, 2025	Awurama Nyarko	Expanded abbreviations on first use per peer review
November 17, 2025	Fei Xie	Implemented TA feedback issues

1 Problem Statement

The following section contains the problem statement, inputs and outputs and stakeholders for the project.

1.1 Problem

Open-source Neural Network (NN) libraries, including training frameworks (e.g., PyTorch, TensorFlow), inference frameworks (e.g., ONNX Runtime), and companion tooling (e.g., data loaders, visualization utilities), are central to academic

research and production Artificial Intelligence (AI) systems. Despite their importance, there is currently no transparent, reproducible, and domain-tailored way to assess the state of software-development practice across these libraries. Existing assessments are typically ad hoc: spreadsheet-based scoring and manual pairwise comparisons (e.g., Analytic Hierarchy Process (AHP)) that are difficult to trace, with evidence scattered across READMEs, documentation, tests, and Continuous Integration (CI) pipelines. This creates challenges for the researchers interested in the result of the assessment and future students who are assessing the state of practice for another domain and want to use a previous assessment as reference.

This project addresses these issues by adapting and applying a rigorous, repeatable state-of-practice methodology to the NN libraries domain, and replacing fragile spreadsheets with a more traceable, auditable tool that streamlines evidence collection, scoring, and ranking. The outcome will be a defensible comparison across software-engineering qualities and actionable recommendations for practitioners and maintainers.

1.2 Inputs and Outputs

Inputs

- Curated set of open-source software libraries that meet inclusion criteria (public repositories with source, installation docs, runnable examples/tutorials).
- Public artifacts: source code, documentation, tutorials, tests, CI configs, issue trackers, release notes.
- Repository measures: commit/issue activity, language breakdown, lines-of-code counts, collected via automated scripts.
- Measurement template responses: structured question bank per quality, completed via automation and human inspection.
- Decision-model configuration: weights over qualities (installability, maintainability, etc.) using a method such as AHP for reproducible rankings.
- Optional practitioner/maintainer interviews, if time permits.

Outputs

- Traceable dataset: structured table recording evidence and normalized scores per software quality.
- Rankings and sensitivity analyses: transparent results with full evidence trail, plus stability testing under weight changes.
- Domain insights: summarized patterns, practice gaps, correlations across projects.

- Recommendations: prioritized, evidence-backed suggestions for maintainers and users.
- Lightweight tool: simple replacement for spreadsheets to collect evidence, apply scoring, and export results (CSV/PDF).
- Research deliverables: (i) an academic-style report documenting methods, dataset, findings; (ii) an open data/software package (versioned with changelog) for reproducibility and reuse.

1.3 Stakeholders

Primary Stakeholders

- **Supervisor:** Owner of the tool, has the final say in the design and implementation of the tool.
- **Future Master's Students:** Users of the tools, using it to store data for the domain they're assessing

Secondary Stakeholders

- **Library maintainers and contributors:** benefit from diagnostics of their library
- **Research software community:** gains reusable tool, single point of access for best practice data on domains.
- **Course instruction team:** evaluates rigor, scope fit, and completeness of methodology and reporting.

1.4 Environment

The following contain the environment required for the development and maintenance of the tool. Users of the tool do not need these in order to access and use the tool.

Hardware & Execution Environment

- **Storage:** a Solid-State Drive (SSD) for fast data access
- **Central Processing Unit (CPU):** Multi-core processor to handle user requests
- **Web Server:** Used to store, process, deliver content

Software & Tooling

- **Operating System:** Linux to follow industry standards for web pages

Assumptions

- Target libraries expose public repositories with source code.

- Installation documentation is available.
- Software qualities can be evaluated from surface artifacts within the project timeline.
- Stakeholders are available for periodic reviews.

Constraints

- Fixed academic timeline.
- Private or internal artifacts excluded.
- Interviews optional and subject to limited availability.
- Rapid upstream changes mitigated via timestamped data collection.

Out of Scope

- Benchmarking model accuracy.
- Benchmarking runtime or throughput performance.
- Domain-specific fitness evaluations beyond software-engineering qualities.

2 Goals

We will develop a tool with several key features to minimize manual effort and improve data management for gathering the data required for the domain assessment. A research paper will also be written in parallel on the NN libraries domain using the tool.

2.1 Research

At the end of our research we will have developed a research paper evaluate and understand the state of development practices within the NN libraries domain. Through this research paper we are aiming answer the questions mentioned in the Methodology for Assessing the State of the Practice for Domain X paper, which are as follows:

- **Development and Technical Stack:** What are the common tools and methodologies used to build and manage these software packages?
- **Developer Experience:** What are the main challenges that developer face and how could they be resolved to improve development process and software quality?
- **Quality and Best Practices:** What actions are developers taking to ensure key software quality (e.g. usability, maintainability, and reproducibility)?
- **Quality Comparison:** How does a library's technical quality, as designed by this research methodology, compare to it's reputation within the broader developer community?

2.2 Tool

The tool will provide a centralized source for the data gathered across all assessed domain.

- **Interactive Data Table:** This feature will provide a visually appealing and intuitive table, allowing researchers to directly edit and manage the database with a user-friendly interface.
Fit Criterion: At least 80% of users (team and pilot testers) will rate the table ≥ 4 out of 5 in usability and visual clarity during internal evaluation.
- **Automated Data Collection:** The tool will automatically collect specific data points using Application Programming Interfaces (APIs) to reduce manual work and errors.
Fit Criterion: Automation successfully retrieves and populates at least 90% of targeted metrics (e.g., commits, issues) without human intervention.
- **Automated Analytic Hierarchy Process (AHP):** The tool will implement an automated AHP to compare libraries, guiding users through pairwise comparisons to weigh criteria and evaluate alternatives.
Fit Criterion: Automated AHP results match expected manual calculations within $\pm 2\%$ variance for all tested scenarios.
- **Data Visualization and Download:** The tool will enable researchers to view and filter results as graphs and export them in varying.
Fit Criterion: Visualizations correctly represent the underlying data and are exportable in all supported formats without error.
- **Collaboration:** The tool will allow domain experts to vet software lists and provide feedback while supporting simultaneous data entry by up to two users.
Fit Criterion: Concurrent editing produces no data conflicts in 95% of test cases and records accurate change logs.

3 Stretch Goals

The following are possible features that can be added to the tool however are not the focus.

- **Traceability:** Currently, the use of Excel sheets makes it difficult to track who made what changes and when. Our tool will include a feature that logs all updates, creating a clear history of changes and improving the accountability of the database.
- **Research Paper Generation:** This feature will allow researchers to write up their findings directly on the tool. It will automatically compile important graphs and tables and format the final document in a user's

preferred style, eliminating the need for manual formatting or direct use of LaTeX.

- **Increase Library Features:** While the current methodology focuses on evaluating development practices, we will expand our data collection to include information on a library’s specific features and capabilities. This will add a new level of functionality, ensuring the tool can recommend a library that not only follows best practices but also aligns with a user’s specific needs.
- **Interactive Dashboard:** This dashboard will provide a centralized, real-time overview of the project’s progress. It will visually highlight key milestones, identify the next steps, and clearly show any missing data or required feedback from domain experts.

4 Extras

Following a discussion with our supervisor, Dr. Spencer Smith, it confirmed that a research paper will serve as our extra and that there will be no need to have another. An academic-style report documenting the findings for the NN domain using the state of best practice methodology ([Smith et al. \(October 2021\)](#)) and the developed tool. For more information on the paper’s scope and purpose, please refer to subsection [2.1 Research](#).

References

Spencer Smith, Jacques Carette, Peter Michalski, Ao Dong, and Olu Owojaiye. Methodology for assessing the state of the practice for domain x. *arXiv preprint arXiv:2110.11575v1*, abs/2110.11575:1–15, October 2021. URL <https://arxiv.org/abs/2110.11575>.

Appendix — Reflection

1. What went well while writing this deliverable?

Awurama: I found that structuring the problem into the four subsections (Problem, Inputs/Outputs, Stakeholders, Environment) went smoothly. Having my draft already written in a google doc made it much easier to adapt to LaTeX.

Ghena: I was able to shift my perspective on the problem after having a meeting with our supervisor, which lead to a more accurate understanding of the PS and goals.

Fei: While writing the deliverable, we were able to as a team have a deeper understanding of what this project is about, and solidify what our own expectations were for this project, through the goals determined and problem statement.

Haniye: Working together on the goals and problem statement helped us see the project from different angles. By sharing our perspectives, we were able to clarify the goals and cover more aspects of the problem than we would have on our own.

2. What pain points did you experience during this deliverable, and how did you resolve them?

Awurama: My main challenge was getting familiar with the LaTeX template and re-adjusting to the GitHub workflow after not using it for a while. I overcame this by researching LaTeX best practices and following the problem statement writing checklist to make sure I stayed on track.

Ghena: Initially, my understanding of the problem statement was centered on the operational challenges faced by researchers, rather than the foundational importance of the research itself. A clarifying discussion with Dr. Smith provided the crucial insight needed to reframe my thinking, enabling me to grasp the project's broader significance. This adjustment allowed me to understand the problem statement and goals that was much more aligned with the supervisor's expectations and the project's core purpose. Need to get better at taking meeting notes.

Fei: Due to the two parts of this project, some members of the team took longer to understand the research side, which affect the understanding of what is required for the tool (i.e. what does the data look like). While writing this deliverable, we were able to identify the aspects that weren't

as clear, and schedule meetings with our supervisor to clarify it for everyone.

Haniye: In the beginning it was a bit confusing to figure out what exactly we should write in the problem statement since the project has both a research side and a tool side. We sometimes wrote a part and then realized we needed to change it as new ideas came up. Meeting with our supervisor really helped us clear the confusion and know how to move forward.

3. How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?

Awurama: As a team, we agreed to keep the project focused on assessing software-engineering practices of neural network libraries, and to exclude accuracy and performance benchmarking. This adjustment kept the scope realistic for the Capstone timeline and ensured it matched the course expectations.

Ghena: Through our meeting with our supervisor, we were able to adjust the scope of our goals to ensure they are suitable for a Capstone project. We discussed what the expected results are and what would be possible add-ons if we had time.

Fei: By interacting with our supervisor early on in the process about what the team thought the expectations were, we were able to quickly narrow down the focus, leveraging the expertise of our supervisor on their past expertise of overseeing numerous past capstone projects. Identifying what were the base functionality compared to “nice-to-have’s” were also important. That way we can ensure we at least finish the project, instead of being stuck in development trying to implement something that is just a cool feature.

Haniye: Talking with our supervisor and sharing our ideas helped us figure out what was most important to focus on and what we could leave out for later. It made it easier to set realistic goals for the Capstone timeline. Our past group project experience also helped us know how to keep things practical.