Reflection and Traceability Report on Image Feature Correspondences for Camera Calibration

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1 Changes in Response to Feedback

1.1 SRS and Hazard Analysis

Hazard Analysis was determined to exceed the scope of work for the development of the Image Feature Correspondences for Camera Calibration software. This software will not be used in real-time or safety critical applications.

Version 1.0 of the **SRS** was published under commit **8776a2b**. Version 2.0 of the **SRS** was published under commit **d139755**.

Software Requirements Specification Revision Summary

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: The *Table of Units* was not applicable to the software system.
  Action Taken: The table was removed from the document.
  Commit: c7d6830

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: Inconsistent symbol definitions across theoretical models, instance models, and data definitions.
  Action Taken: The *Table of Symbols* was updated for consistency across all sections.
  Commit: 6c49512

- **Source of Feedback:** GitHub Issue #4
  Issue Identified: Expected user inputs and responsibilities were unclear in the System Context Diagram.
  Action Taken: Diagram and descriptive text were revised to clarify user input responsibilities.
  Commit: 86e483c

- **Source of Feedback:** Instructor (verbal) during VnV Plan discussion
  Issue Identified: Lack of documentation for OpenCV-based constraints.
  Action Taken: A new system constraint based on OpenCV limitations

was added.
Commit: c7d6830

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: Definition of extrinsic parameters was vague.
  Action Taken: Definition of extrinsic parameters was clarified.
  Commit: e0236d3

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: Requirement GS5 was outdated and unclear.
  Action Taken: Replaced GS5 with new requirement R15 for feature correspondence reporting.
  Commit: 6c9a58a

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: Requirements GS1 and GS2 were no longer needed.
  Action Taken: GS1 and GS2 were removed.
  Commit: e0236d3

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: Theoretical and instance models used inconsistent or unclear notation.
  Action Taken: TM01–TM04 and IM01–IM04 were revised for consistent mathematical presentation.
  Commit: 6c49512

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: The definition of the XOR operation in TM4 was unclear.
  Action Taken: Improved definition and symbolic notation for XOR was added.
  Commits: c7d6830, 6c49512

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: IM01 lacked detailed steps for computing the Gaussian-smoothed image.
  Action Taken: IM01 was expanded to include a full description of the required computation steps.
  Commit: 6c49512

- **Source of Feedback:** GitHub Issue #2
  Issue Identified: No non-functional requirements for software quality were provided.
  Action Taken: Added five non-functional requirements (NFR1–NFR5) covering reliability, usability, maintainability, and performance.
  Commit: 6c9a58a

- **Source of Feedback:** GitHub Issue #5
  Issue Identified: Table of Symbols was not consistent with mathematical

models.

Action Taken: Table of Symbols was updated to align with definitions and notation in theoretical and instance models.

Commit: 6c49512

1.2 Design and Design Documentation

Version 1.0 of the **MG** was published under commit **75b68fc**. Version 2.0 of the **MG** was published under commit **f7b81b4**.

Module Guide Revision Summary

- **Source of Feedback:** GitHub Issue #17
  Issue Identified: Minor grammatical and formatting errata were present in Revision 1.0 of the Module Guide.
  Action Taken: All minor grammar and formatting issues were corrected.
  Commit: b71d13a

- **Source of Feedback:** GitHub Issue #18 (AC12) and GitHub Issue #19 (AC13)
  Issue Identified: Both issues requested clarification on how anticipated changes (AC12 and AC13) impact software design.
  Action Taken:

  - AC12 was rewritten to emphasize the design implications rather than user interaction.

  - AC13 was removed due to significant overlap with the revised AC12.

  Commit: f7b81b4

- **Source of Feedback:** GitHub Issue #20
  Issue Identified: The Control Module was described as an abstract data type rather than an abstract object.
  Action Taken: The description of the Control Module was revised to reflect it as an abstract object.
  Commit: b71d13a

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: A link to the VnV Plan was not provided in the Module Guide.
  Action Taken: An explicit reference to the VnV Plan was added to the Module Guide.
  Commit: b71d13a

- **Source of Feedback:** GitHub Issue #15
  Issue Identified: It was suggested that a graphical user interface (GUI) be added to support image display in M11 (Image Plot Module).
  Action Taken: No change was made. It was determined that image

generation using OpenCV functions like `imwrite()`, `drawKeypoints()`, and `drawMatches()` was sufficient, and GUI development was outside the project scope.
Commit: Not applicable (no changes made).

Version 1.0 of the **MIS** was published under commit **75b68fc**. Version 2.0 of the **MIS** was published under commit **9f9e07a**.

Module Interface Specification (MIS) Revision Summary

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: OpenCV class data in Section 4 duplicated content from Section 16.
  Action Taken: Redundant content in Section 4 was removed to avoid duplication.
  Commit: 9f9e07a

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: Question raised about enumerating available image processing methods in Section 6.4.1.
  Action Taken: No action taken. Justification was provided: all available methods are presented to the user dynamically via Specification Parameters Module and validated in the Input Format Module.
  Commit: 9f9e07a

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: Path strings used as environment variables were not defined as state variables.
  Action Taken: Path strings were reclassified as state variables, including similar updates in Sections 7.4.2 and 9.4.2.
  Commit: 9f9e07a

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: Method calls lacked explicit module references in Section 6.4.4.
  Action Taken: All method calls were updated to include explicit module prefixes (e.g., `config.get_active_methods()`).
  Commit: 9f9e07a

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: `getcwd()` was incorrectly attributed to the Python `Path` class in Section 7.4.4.
  Action Taken: Corrected to state that `getcwd()` belongs to the `os` module and clarified its output semantics.
  Commit: 9f9e07a

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: The `check_limits()` method in Section 7.4.4 had undefined arguments.

Action Taken: Method signature was updated to include the appropriate tuning parameter arguments.
Commit: 9f9e07a

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: Tuning parameters in Sections 8.3 and 8.4 were redundantly defined as both exported constants and state variables.
  Action Taken: Removed state variable definitions to retain only exported constants.
  Commit: 9f9e07a

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: Suggested that method variables (e.g., `mthd_...`) in Section 8.3.1 should be booleans.
  Action Taken: Suggestion was kindly rejected. Method identifiers remain as integers to support enumerated selections for future extensibility.
  Commit: Not applicable (no change implemented)

- **Source of Feedback:** GitHub Issue #21
  Issue Identified: `make_directory(folder_name)` in Section 9.4.4 did not clarify its effect on environment variables.
  Action Taken: Semantics were updated to specify that this function causes an environment variable transition.
  Commit: 9f9e07a

1.3   VnV Plan and Report

Version 1.0 of the **VnV Plan** was published under commit **f73ef27**. Version 2.0 of the **VnV Plan** was published under commit **d139755**.

Version 1.0 of the **VnV Report** was published under commit **d139755**. No feedback has been received to propose additional revisions.

Verification and Validation Plan Revision Summary

- **Source of Feedback:** GitHub Issue #9
  Issue Identified: The course name "CAS 741" was mentioned within the VnV Plan, which is not appropriate.
  Action Taken: All references to "CAS 741" were removed from the VnV Plan.
  Commit: e67619f

- **Source of Feedback:** GitHub Issue #10
  Issue Identified: Relevant documents were missing from Section 2.4 (Relevant Documentation).
  Action Taken: Section 2.4 was updated to include descriptions of the

SRS, MG, and MIS.
Commits: bec8167, 66fa0a4

- **Source of Feedback:** GitHub Issue #11
  Issue Identified: Minor errata were present, including incorrect table placement, inconsistent acronym/symbol usage, and test numbering errors.
  Action Taken: All identified errata were corrected throughout the VnV Plan.
  Commit: e67619f

- **Source of Feedback:** GitHub Issue #12
  Issue Identified: Reference to ArUco markers created the impression that only ArUco was acceptable.
  Action Taken: Reference to ArUco was removed and replaced with a general term: "generated binary markers".
  Commit: f73ef27

- **Source of Feedback:** GitHub Issue #13
  Issue Identified: System tests STFR-KP-01 and STFR-DC-01 lacked clear traceability to R6 and R8.
  Action Taken: Method flags were added to both tests to identify that corner detection and Hamming distance comparisons were used, respectively.
  Commit: 60dac24

- **Source of Feedback:** GitHub Issue #14
  Issue Identified: Requirement R4 and its connection to STFR-FD-01 lacked a clear definition of descriptor bin size.
  Action Taken: Descriptor bin size was explicitly defined in the Table of Symbols and the STFR-FD-01 input section.
  Commit: f298373

- **Source of Feedback:** GitHub Issue #7 (Software Design Instructor)
  Issue Identified: Symbols table contained unused entries not referenced in the VnV Plan.
  Action Taken: Symbols table was reduced to only include symbols and abbreviations used in the document.
  Commit: bec8167

- **Source of Feedback:** GitHub Issue #7
  Issue Identified: Section 2.3 lacked specification of the challenge level of the project.
  Action Taken: Section 2.3 was updated to state that the project is a research-level front-end to a camera calibration pipeline.
  Commit: 86e483c

- **Source of Feedback:** GitHub Issue #7
  Issue Identified: Reference documents PS, SRS, MG, and MIG were

not mentioned in the VnV Plan.
Action Taken: These documents were listed and described in Section 2.4.
Commits: bec8167, 66fa0a4

- **Source of Feedback:** GitHub Issue #7
  Issue Identified: The proposed Software Validation Plan simply duplicated verification activities and did not reflect actual validation.
  Action Taken: Validation was identified as out of scope and the section was updated accordingly.
  Commit: 86e483c

- **Source of Feedback:** GitHub Issue #7
  Issue Identified: System tests lacked specific parameter values for each scenario.
  Action Taken: STFR-IS-01, STFR-KP-01, STFR-FD-01, and STFR-FM-01 were each updated to include well-defined test inputs and parameters.
  Commit: 86e483c

- **Source of Feedback:** GitHub Issue #7
  Issue Identified: Definition of a "match" was missing in STFR-FM-01.
  Action Taken: A clear definition of a match was added to STFR-FM-01.
  Commit: 86e483c

2 Challenge Level and Extras

2.1 Challenge Level

This project is defined as an advanced research project. The output of the Image Feature Correspondences for Camera Calibration software form the front end of a robust optimization algorithm for extrinsic camera calibration. The framework of this software will be iterated upon during the Summer 2025 development period and beyond to collect meaningful input data to test the backend of the optimization software.

2.2 Extras

No extra deliverables will be delivered with this project.

3 Design Iteration (LO11 (PrototypeIterate))

[Explain how you arrived at your final design and implementation. How did the design evolve from the first version to the final version? —TPLT]

[Don't just say what you changed, say why you changed it. The needs of the client should be part of the explanation. For example, if you made changes in

response to usability testing, explain what the testing found and what changes it led to. —TPLT]

4 Design Decisions (LO12)

[Reflect and justify your design decisions. How did limitations, assumptions, and constraints influence your decisions? Discuss each of these separately. —TPLT]

5 Economic Considerations (LO23)

[Is there a market for your product? What would be involved in marketing your product? What is your estimate of the cost to produce a version that you could sell? What would you charge for your product? How many units would you have to sell to make money? If your product isn't something that would be sold, like an open source project, how would you go about attracting users? How many potential users currently exist? —TPLT]

6 Reflection on Project Management (LO24)

[This question focuses on processes and tools used for project management. —TPLT]

6.1 How Does Your Project Management Compare to Your Development Plan

[Did you follow your Development plan, with respect to the team meeting plan, team communication plan, team member roles and workflow plan. Did you use the technology you planned on using? —TPLT]

6.2 What Went Well?

[What went well for your project management in terms of processes and technology? —TPLT]

6.3 What Went Wrong?

[What went wrong in terms of processes and technology? —TPLT]

6.4 What Would you Do Differently Next Time?

[What will you do differently for your next project? —TPLT]