

AFRETEC NETWORK IDT RESEACH FUNDING PERIODIC NARRATIVE REPORT

Report Submitted By

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INSTRUCTIONS

Partner: Please refer to the original Inclusive Digital Transformation Africa Research Proposal when answering these questions, as relevant. Upon completion, please email this report to CMU-Africa at afretec@andrew.cmu.edu.

GENERAL INFORMATION

Organization Name:

Reporting Period: 2024

☐ January- June

☒ July- December

1. REPORTING PERIOD SUMMARY

1.1 Activity Achievements

Outline your key achievements that occurred during this reporting period. What factors do you think contributed to these achievements? Please consider and include achievements that touch on inclusion.

Achievements:

D. Vernon, “Keynote Talk: Culturally Sensitive Social Robots for Africa”, [Robotics in Africa Forum](#) at [IROS 2024](#). Available [here](#).

Continual maintenance of the project website www.cssr4africa.org and [wiki](#), including continually updated [News](#), [Deliverables](#), and [Publications](#) pages.

Continual update of a comprehensive 96-page [work plan](#) (see the document history at the end of the report to view the updates in versions 2.20 – 2.24 made in the current reporting period).

Completion of six [deliverables](#):

[D5.2 Animate Behavior Subsystem](#) (v1.0).

[D5.3 Attention Subsystem](#) (v1.0).

[D5.4.1 Cultural Knowledge Ontology & Knowledge Base](#) (v1.0).

[D5.4.3 Robot Mission Interpreter](#) (v1.0).

[D5.5.1 Gesture Execution](#) (v1.0).

[D5.5.1.L Programming by Demonstration](#) (v1.0).

Revision of eight [deliverables](#):

[D1.2 Rwandan Cultural Knowledge, version 1](#) (v1.8 – v2.4).

[D3.1 System Architecture, version 1](#) (v1.4 – v1.8).

[D3.2 Software Engineering Standards Manual](#) (v1.8 – v1.11).

[D3.3 Software Installation Manual](#) (v1.5).

[D3.4 System Integration and Quality Assurance Manual](#) (v1.1 – v1.4).

[D7.3 Open-Source Software Repository](#) (commits on 21 August).

[D8.1 Progress Report](#) (v3.0).

[D8.2 Expenditure Report](#) (v3.0).

Maintenance of seven [deliverables](#):

- [D2.2 Robot Behavior Specification, version 1](#) (v1.2).
- [D2.3 Visitor Behavior Specification, version 1](#) (v1.0).
- [D3.5 System Integration and Quality Assurance](#) (v1.0).
- [D4.1 Sensor Tests](#) (v1.0).
- [D4.2.1 Person Detection and Localization](#) (v1.0).
- [D5.1 Actuator Tests](#) (v1.0).
- [D7.1 Online Presence](#) (v1.1).

Presentation of three posters at the [Robotics in Africa Forum](#) at [IROS 2024](#).

- 1) Akinade and D. Vernon, “Biological Motion for Gestural Communication by Social Robots”, [Robotics in Africa Forum](#) at [IROS 2024](#). Available [here](#).
- 2) E. Birhan and D. Vernon, “Rwandan Culture Survey for Culturally-Sensitive Social Robotics for Africa”, [Robotics in Africa Forum](#) at [IROS 2024](#). Available [here](#).
- 3) Jimoh, H. Equbay, C. Osano, T. Tefferi, and D. Vernon, “Behavior Trees for Culturally Sensitive Social Robots: African Culture Case Study”, [Robotics in Africa Forum](#) at [IROS 2024](#). Available [here](#).

Completion of a survey to acquire cultural knowledge about how to interact respectfully with people in Rwanda. The knowledge that is gathered will be used by our social robots when they engage with people, informing their verbal, non-verbal, and spatial interaction. The survey is available in Kinyarwanda [here](#) and in English [here](#). See Deliverables [D1.2](#) and [D5.4.1](#) for the results of the survey.

Publications

D. Vernon, 2024. “An African Perspective on Culturally Competent Social Robotics: Why DEI Matters in HRI”, IEEE Robotics and Automation Magazine, Vol. 31, No. 4, pp. 170-200. Available [here](#).

Factors of Success:

- ☐ Careful, thorough planning and re-planning (cf. the [work plan](#) above) with which all members of the team are thoroughly familiar.
- ☐ Having a team with critical mass in terms of number and background; ten research assistants/associates work on the project in the current period. Nine research associates will work on the project in the next period.
- ☐ Having a complete, detailed, up-to-date [system architecture](#) with which all members of the team are thoroughly familiar.
- ☐ The involvement of dedicated research associates at CMU-Africa: Adedayo Akinade, Eyerusalem Birhan, Muhammed Danso, Yohannes Haile, and Tsegazeab Taye Tefferi, all of whom received intensive training.
- ☐ The involvement of summer interns at CMU-Africa from 3 June: Daniel Barros, Heran Equbay, Birhanu Shimelis Girma, Ibrahim Jimoh, Clifford Osano, and Muhirwa Richard, all of whom received intensive training.
- ☐ Hands-on project management, with adjustment of the work plan, when appropriate.
- ☐ The ability to purchase new and replacement equipment in a timely manner.
- ☐ Weekly project team meetings and weekly task team meetings.
- ☐ Weekly individual progress reports and weekly task progress reports.

1.2 Activity Learnings

What key lessons did you learn during this reporting period (e.g. through the process of design and implementation of Activities). Include learnings that touch on inclusion. Outline 3 key lessons that emerged during this reporting period. *Add rows as needed.*

Lesson 1: A detailed, comprehensive, up-to-date work plan is essential.

Lesson 2: An agile approach is critical for success so that changes in circumstances can be quickly accommodated (e.g., the need for CMU-Africa to step in and work on Deliverables D5.4.1, D5.4.2, D5.4.3, D5.5.2.1, and D5.5.2.4 in lieu of Wits).

Lesson 3: Weekly project group meetings are essential but they need to be augmented by weekly task team meetings, and occasional one-on-one meetings.

Lesson 4: Delays are inevitable: the best laid plans cannot account for all eventualities, e.g., poor performance of components in the Pepper robot, and contingency plans are essential. Purchasing a second Pepper robot, additional sensors and processors, specifically a LiDAR, Raspberry Pi with a GPU, and Lenovo laptop with a GPU, were pivotal in keeping project momentum.

Lesson 5: It takes time for interns to transition from a group-work mentality to a team-work mentality, in which responsibility is shared, and to shift from a student-mode of work to a professional-mode of work, respecting deadlines and, especially, understanding that quality output requires a huge investment on time.

Lesson 6: Monthly demo sessions provide a very effective catalyst for driving and monitoring progress.



1.3 Progress & Impact

Use the tables below to report numerical targets, results, and relevant explanations or comments. If any internal or external factors may influence progress, please explain. All quantitative indicators should be disaggregated by gender, and where possible and relevant, by age groups, disability status, rural/urban, degree program, etc.

1.3.1: Progress Reporting (Outputs): Progress reporting shows the outputs of the Activity. In the table below, please provide updates on your progress of funded Activities. Examples of progress indicators include the gender representation of students/ learners/ faculty receiving support, number of Afretec and non-network universities partnered with, or share of participants who successfully completed training or education out of the total target. *Add rows as needed.*

| Progress Reporting | Indicators (quantitative or qualitative) | Target | Results to date (include gender & other disaggregation as relevant) | Comments on progress (any insights, opportunities to adapt, etc.) |
|--------------------|---|--------------------|--|---|
| Deliverables | Submission to website | 27 deliverables | 21 delivered | <p>The remaining deliverables are delayed by approx. 3-6 months.</p> <p>There are two primary causes of these delays. The first is the time and effort required to develop software that complies with the CSSR4Africa software engineering standards, as set out in Deliverable D3.2.</p> <p>The second was the need to deploy effort to undertake five critical path tasks originally assigned to WITS, viz.</p> <p>D5.4.1 Cultural Knowledge Ontology & Knowledge Base D5.4.2 Robot Mission Language D5.4.3 Robot Mission Interpreter D5.5.2.1 English Text to Speech Conversion D5.5.2.4 Integrated Text to Speech Conversion</p> <p>We also undertook an additional task D5.5.1.L Programming by Demonstration.</p> <p>Finally, a significant amount of time was devoted to writing a paper for the International Journal of Humanoid robotics, and responding to reviewer comments, requiring the additional experiments work. We are about to submit the third, and hopefully final version of this paper.</p> |
| Diversity | Balance of female/male research assistants | Equal balance | Two of eight RAs are female | The achievable balance reflects the balance of CMU-Africa students taking robotics courses. |



| | | | | |
|---------------|----------|--------|--|---|
| Collaboration | Meetings | Weekly | Approx. 90% of weekly meetings were held | As noted above, monthly demo sessions provide a very effective catalyst for driving and monitoring progress. There has been no formal contact with Wits over the period. |
|---------------|----------|--------|--|---|

Please describe any above-mentioned qualitative indicators that show progress. Examples of qualitative progress indicators are development of a training curriculum, signing of an agreement, etc.

1.3.2: Impact Reporting (Outcomes): Impact monitoring shows the changes or outcomes that occur partly or fully due to the Afretec collaboration and program investment. In the table below, please provide updates on outcomes and/or emerging outcomes. Examples of outcomes include: level of student preparedness for and interest in pursuing graduate education in ICT, assessment of faculty engagement in professional development that enhances their teaching, or evidence of increased collaboration with universities or industry locally and regionally. *Add rows as needed.*

Outcomes should relate specifically to the Afretec Network Principles [**Network-Based, Leveraged, Collaborative, Diverse & Inclusive, Transformative and Evidence-Based**] (see Principles section of Afretec Action Plan). Include in Comments to which Principle the outcome is related.

| Main changes or outcomes (indicate the level the activity is focusing on— learner, student, faculty, institution, industry, country or region) | Indicators (quantitative or qualitative) | Target | Results to date/contribution to impact (include gender & other disaggregation as relevant) | Comments on impact (any insights, opportunities to transform) |
|--|--|---------------------------|---|--|
| Professionalism | Research assistant productivity | 8 RAs/Interns trained | 17 RAs/Interns trained | Comprehensive training material and a period of induction are essential. This material has been made available to other groups and research projects. |
| Technical knowledge & skills | Ability to acquire new technical skills and overcome unforeseen technical problems | Independent learning | Clear evidence of independent learning, varying from moderate to outstanding, depending on the research assistant | It is essential to assign individual responsibilities to encourage the acquisition of new knowledge and skills, and to make it transparently obvious when these skills have been acquired, and the degree to which they have |
| Diversity | Ability to work with people from different cultural and professional backgrounds | 100% cohesion in the team | Most RAs work well together | Diversity adds value as it exposes RAs to different standards and expectations regarding both professionalism and technical competence. |

Describe any emerging effects or changes that are not captured quantitatively. Include both positive or negative changes that were either intended or unintended.

1.3.3. Ripples of Impact: Your intervention may have ripple effects beyond the level identified above. For example, a program targeting young women or men to pursue education or entrepreneurship opportunities may have an impact on their households or communities. A program targeting university- industry relationships may have an impact on recent graduate job placement. Multi-university knowledge creation projects may impact the visibility of African research collaborations to global funding organizations.

We hope to capture the full range of potential ripples of impact and broader changes of Afretec programs, so we may potentially follow up with impact assessments. Please note if any programs that targeted one level (e.g. learner, student, faculty, institution, industry, country or region) are showing ripple effects on other levels:

It is still too early in the project to expect any significant ripple effect. However, one event that highlight the merits of the research and should create a ripple effect is the acceptance of an article in a high-profile journal highlighting the research, viz. D. Vernon, 2024. “An African Perspective on Culturally Competent Social Robotics: Why DEI Matters in HRI”, IEEE Robotics and Automation Magazine, accepted for publication. This will be published in the next period. A preprint available [here](#).

1.3.4: Additional data collection: Please describe any additional quantitative and qualitative data collection efforts utilized (e.g. key interviews and focus group discussions, pre and post program knowledge assessments, attitudes and practices (faculty

or collaboration partner surveys, etc.). This may help identify opportunities to deepen how we capture the impact of this partnership. These efforts could include data collection described in your proposals or any other relevant data collection.

In April we launched a wide-ranging survey in both English and Kinyarwanda to acquire cultural knowledge about how to interact respectfully with people in Rwanda. The knowledge that is gathered will be used by our social robots when they engage with people, informing their verbal, non-verbal, and spatial interaction. Currently, there are 139 respondents. This represents a very significant increase over the number that responded in April. This increase owes much to the recruitment of a Kinyarwanda speaking Intern to promote the survey and assist people taking it.

2. PARTNERSHIP UPDATES

2.1 Partnership Changes

Have there been any key changes (changes with significant impact on partnership or activity success) to any of the following items? ☐ Yes ☒ No

Items: context, outputs/deliverables; key activities; inputs/resources; monitoring, evaluation, research and learning plan; communications approach; team structure (including staffing), etc.

If yes, please describe:

2.2 Collaboration Update

Please provide an update of your engagement and collaboration with partnership stakeholders (e.g. academic institutions, private sector organizations, government organizations, community groups, civil society organizations, etc.) during this reporting period.

The main unplanned engagement and collaboration arose as a result of the [workshop](#) on Culturally Sensitive Social Robotics for All at the 21st International Conference on Advanced Robotics (ICAR 2023), Abu Dhabi, UAE. Collaboration with the invited speaker, Prof. Barbara Bruno, Karlsruhe Institute of Technology, Germany, and Prof. Birgit Lugin, University of Wurzburg, Germany, and attendee, has progressed over the past six months. As a consequence, Prof. Lugin's Ph.D. student, Melissa Donnermann, visited CMU-Africa in from 29 September 2024 – 8th October 2024. During her visit, she conducted a user study on the use of the Pepper robot for as a tutorial assistant. A paper on this study is under preparation.

3. COMMUNICATIONS UPDATE

3.1 Communications Activities Update

Please describe the marketing and communications outreach that occurred during this reporting period as well as any relevant media links.

Hannah Diorio-Toth is pitching the work being done in the project to Nature Africa. We await a positive outcome.

Publications, presentations, and posters on the project are available on the CSSR4Africa website [here](#).

Additional media material includes Tartan Research Spotlight [video](#) on Social Robotics for Africa.

4. RISK UPDATE

4.1 Risk Update

Please provide an update to the risks, either new, as previously identified in the Proposal or previous Periodic Reporting Template. Consider partnership and activity-level (e.g. capability, capacity), and organizational-level (e.g. affecting management, governance, personnel essential to the functioning of the organization).

| Risk | Likelihood | Risk Impact | Risk Mitigation Plan |
|--|------------|-------------|---|
| Inadequate funding for research assistants | Low | High | <p>Pay RAs from alternative funds, e.g., Research Professorship Start-up Fund; agreement has this has already been agreed and the plan has been implemented.</p> <p>Having exhausted the CSSR4Africa budget for Year 2, we are now completely dependent on this source of funding to complete the project.</p> <p>Since this source of funding also expires in June 2025, we plan on wrapping up the project at that point. This date coincides with the departure of the PI from CMU-Africa.</p> |
| The Pepper robot dies again | Moderate | Low | We have purchased a second Pepper robot. |
| Unable to resolve an ongoing control problem requiring termination of the inbuilt autonomous life mode on the Pepper robot | Moderate | Low | We have found a partially effective workaround to this problem. |
| African cultural knowledge are not effective in use cases | Low | High | T6.2 produces a set adjustments which are documented in T1.4. |
| Implementation of the system architecture for use cases is insufficient | Low | High | T6.2 produces a set adjustments which are documented in T3.5. |
| Robot sensing and analysis does not perform adequately | Low | High | T6.2 produces a set adjustments which are documented in T4.4. |
| Robot behaviors do not perform adequately | Low | High | T6.2 produces a set adjustments which are documented in T5.6. |
| T6.4 Use case evaluation does not achieve sufficiently high user ratings in the evaluation | Moderate | Moderate | T6.2 identifies adjustments; these are implemented in T1.4, T2.4, T3.5, T4.4, and T5.6. |

5. NEXT REPORTING PERIOD

5.1 Plans for Next Reporting Period

Based on the Afretec Action Plan and progress updates thus far, please outline your key activities for the next reporting period.

Our priority in the next reporting period is to complete the remaining tasks and commit the associated software to the [CSSR4Africa GitHub repository](#).

| | |
|--------------|---|
| Task 3.5 | System Integration and Quality Assurance |
| Task 4.2.1 | Person Detection and Localization |
| Task 4.2.2 | Face & Mutual Gaze Detection and Localization |
| Task 4.2.3 | Sound Detection and Localization |
| Task 4.2.4 | Robot Localization |
| Task 4.3.2 | Speech Event |
| Task 5.4.2 | Robot Mission Language (being undertaken by CMU-Africa in lieu of Wits) |
| Task 5.5.2.1 | English Text to Speech Conversion (being undertaken by CMU-Africa in lieu of Wits) |
| Task 5.5.2.4 | Integrated Text to Speech Conversion (being undertaken by CMU-Africa in lieu of Wits) |
| Task 5.5.2.3 | Kinyarwanda Text to Speech Conversion |
| Task 5.5.3 | Environment Map Generation |
| Task 5.5.4 | Robot Navigation |

We expect these to be complete in time for the early wrap-up of the project at the end of Year 2 (see note on Risks above).

To ensure that they are, we plan on meeting the following milestones in this final six-month period.

1. Submit remaining deliverables by end of February.
2. Submit all software to GitHub by end of March.
3. Conduct full demo by end of March.
4. Deploy cultural knowledge by end of April.
5. Conduct an open demo by end of May.
6. Complete final report by end of June.

6. ADDITIONAL INFORMATION

6.1 Additional Information

Please describe any additional information that the Director of the Afretec Network should be aware of.

This is a CMU-Africa periodic narrative report. It does not refer to the progress made by The University of the Witwatersrand over the current period. It is noteworthy that there has been no formal contact with the University of the Witwatersrand over the past year; consequently, CMU-Africa has undertaken five tasks originally assigned to Wits (see [Deliverables](#)).

As noted above, the CSSR4Africa budget for Year 2 has been exhausted and we are now completely dependent on the PI's Research Professorship Start-up Fund to complete the project. Since this source of funding also expires in June 2025, we plan on wrapping up the project at that point. This date coincides with the departure of the PI from CMU-Africa.



NOTE: THE FOLLOWING SECTION IS FOR INTERNAL USE AT CMU-AFRICA ONLY.

Associate Director of Impact to complete this section following submission of the Periodic Narrative Report by the Afretec Partner.

7. REVIEW

7.1 Associate Director of Impact Comments

Please describe any key issues and/or follow-up items and provide a summary of discussions that occurred with partners during this reporting period.