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: 2025 ☑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, "An African Perspective on Culturally Competent Social Robotics: Why DEI Matters in Human-Robot Interaction", Breaking Barriers Through Technology Webinar, Afretec Network. Available here.

Continual maintenance of the project website www.cssr4africa.org and wiki, including periodically 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 2.25 – 3.6 made in the current reporting period).

Completion, revision, and curation of 33 deliverables:

D1.2	Rwandan Cultural Knowledge, version 1
D2.1	Use Case Scenario Definition, version 1
D2.2	Robot Behavior Specification, version 1
D2.3	Visitor Behavior Specification, version 1
D3.1	System Architecture, version 1
D3.2	Software Engineering Standards Manual
D3.3	Software Installation Manual
D3.4	System Integration and Quality Assurance Manual
D3.5	System Integration and Quality Assurance
D4.1	Sensor Tests
D4.2.1	Person Detection and Localization
D4.2.2	Face & Mutual Gaze Detection and Localization
D4.2.3	Sound Detection and Localization
D4.2.4	Robot Localization
D4.3.2	Speech Event
D5.1	Actuator Tests

D5.2	Animate Behavior Subsystem
D5.3	Attention Subsystem
D5.4.1	Cultural Knowledge Ontology & Culture Knowledge Base
D5.4.2	Robot Mission Language
D5.4.3	Robot Mission Interpreter
D5.5.1.1	Gesture Execution
D5.5.1.2	Programming by Demonstration
D5.5.2.1	English Text to Speech Conversion
D5.5.2.3	Kinyarwanda Text to Speech Conversion
D5.5.2.4	Integrated Text to Speech Conversion
D5.5.3	Environment Map Generation
D5.5.4	Robot Navigation
D6.1	Use Case Implementation
D6.2	Use Case Evaluation
D7.1	Online Presence
D7.3	Open-Source Software Repository
D8.1	Progress Report

All deliverables due by 30 June 2025 for which CMU-Africa is responsible in the work plan, or for which CMU-Africa had assumed responsibility in lieu of delivery by Wits, have been completed and uploaded to the CSSR4Africa website.

Poster placed third at the Afretec Network Principal Investigators Meeting: A. Akinade, D. Barros, M. Danso, Y. Haile, E. Birhan, B. Shimelis Girma, C. Osano, P. Ranchod, M. Richard, B. Rosman, I. Jimoh, T. Taye Tefferi, D. Vernon, "Culturally Sensitive Social Robotics for Africa", Available here.

First successful demonstration of the Lab Tour use case scenario, involving the integration of all twelve ROS nodes in the system architecture.

Publications

A. Akinade, D. Barros, and D. Vernon, "Biological Motion Aids Gestural Communication by Humanoid Social Robots", International Journal of Humanoid Robotics, 2025. Available here.

A. Akinade, D. Barros, M. Danso, Y. Haile, E. Birhan, B. Shimelis Girma, C. Osano, P. Ranchod, M. Richard, B. Rosman, I. Jimoh, T. Taye Tefferi, D. Vernon, "Culturally Sensitive Social Robotics for Africa", Proceedings of the 2nd International Workshop on Cultural Robotics: Diversified Sustainable Practices, IEEE/ACM HRI 2025, Springer LNAI, in press. Submission available here.

Factors of Success:

- Preparation and continual update of a detailed work plan with which all members of the team are thoroughly familiar.
- Having a team with critical mass in terms of number and background; nine RAs worked on the project in the current period.
- Having a complete, detailed, up-to-date system architecture with which all members of the team are thoroughly familiar.
- The involvement of full-time research associates at CMU-Africa: Adedayo Akinade, Birhanu Shimelis Girma Eyerusalem Birhan, Muhammed Danso, Muhirwa Richard, Tsegazeab Taye Tefferi, and Yohannes Haile, all of whom received intensive training.
- The involvement of part-time research assistants Clifford Osano and Ibrahim Jimoh, both of whom received intensive training.
- Hands-on project management, with adjustment of the work plan, when appropriate.
- Weekly project team meetings and weekly task team meetings.
- Weekly task progress reports.
- Embracing the complexity of systems engineering and focusing on periodic demonstrations.

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 Task 5.4.1 Cultural Knowledge Ontology & Culture Knowledge Base, Task 5.4.2 Robot Mission Language, Task 5.4.3 Robot Mission Interpreter, Task 5.5.2.1 English Text to Speech Conversion, Task 5.5.4.2 Integrated Text to Speech Conversion, Task 6.1 Use Case Implementation, and Task 6.2 Use Case Evaluation in lieu of Wits).

Lesson 3: Weekly project group meetings are essential, with a prepared agenda circulated in advance of the meetings, and formal minutes circulated after the meeting. The minutes must include a list of action items assigned to members of the team. Progress on these action items are reviewed at the next meeting.

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 research assistants and associates 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 heavy investment of time.

Lesson 6: Having team members review the deliverables written by other members of the team is very helpful for quality assurance.

Lesson 7: Having a formal software engineering standards, an associated quality assurance process, and a dedicated RA to check compliance with the standards is invaluable.

Lesson 8: Monthly demonstrations 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	33 deliverables	33 delivered	Delays with completion of deliverables reported in the previous period have been eliminated. **All deliverables due by 30 June 2025 for which CMU-Africa is responsible in the work plan, or for which CMU-Africa had assumed responsibility in lieu of delivery by Wits, have been completed and uploaded to the CSSR4Africa website.** Fifteen of these deliverables have software elements in the form of ROS nodes. Fourteen of these have been submitted for integration. Of these, eight demonstrated compliance with the CSSR4Africa software engineering standards and have been accepted and included in the CSSR4Africa software repository on GitHub. We achieved the first successful demonstration of the Lab Tour use case scenario. Note that to achieve this, it was necessary for CMU-Africa to take responsibility for seven tasks originally assigned to Wits, due to delays in the delivery of a Pepper robot to Wits, as follows. Task 5.4.1 Cultural Knowledge Ontology & Culture Knowledge Base, Task 5.4.2 Robot Mission Language, Task 5.4.3 Robot Mission Interpreter, Task 5.5.2.1 English Text to Speech Conversion, Task 5.5.4.2 Integrated Text to Speech Conversion, Task 6.1 Use Case Implementation, and Task 6.2 Use Case Evaluation

Diversity	Balance of female/male research assistants	Equal balance	One of the nine RAs is female	The achievable balance reflects the balance of CMU-Africa students taking robotics courses.
Collaboration	Meetings	Weekly	Approx. 95% of weekly meetings were held	As noted above, monthly demo sessions provide a very effective catalyst for driving and monitoring progress. Formal contact with Wits resumed in this period and the Co-PI from Wits represented the project at the Principal Investigator Meeting in Kigali in June.

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	16 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 good 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, December 2024. A copy is available is 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 2024, 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 at first. 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.

As noted in the previous progress report, collaboration has progressed over the past six months with Prof. Barbara Bruno, Karlsruhe Institute of Technology, Germany, Prof. Birgit Lugrin, University of Wurzburg, Germany, Prof. Lugrin's Ph.D. student, Melissa Donnermann, and Daniel Barros, Technical University of Munich, Germany (an intern at CMU-Africa in the previous period). We are currently working on a paper that leverages the work described in Deliverable D5.5.1.2 Programming by Demonstration.

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.

David Vernon gave a talk, "An African Perspective on Culturally Competent Social Robotics: Why DEI Matters in Human-Robot Interaction", as part of the Breaking Barriers Through Technology Webinar, Afretec Network. A copy is available here.

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

Journal papers, conference papers, workshop papers, abstracts, posters, and talks & presentations 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	Pay RAs from alternative funds, e.g., Research Professorship Start-up Fund; this has this has been agreed and the plan has been implemented. We have sufficient funds in Year 3 to continue to employ two, possibly three, research associates to complete the project. The original PI at CMU-Africa, David Vernon, is retiring and is being replaced by Assane Gueye.
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	D6.2 documents the required changes to be implemented in Year 3 in Tasks 1.4, 2.4, 3.5, 4.4, and 5.6.
Implementation of the system architecture for use cases is insufficient	Low	High	D6.2 documents the required changes to be implemented in Year 3 in Tasks 1.4, 2.4, 3.5, 4.4, and 5.6.
Robot sensing and analysis does not perform adequately	Low	High	D6.2 documents the required changes to be implemented in Year 3 in Tasks 1.4, 2.4, 3.5, 4.4, and 5.6.
Robot behaviors do not perform adequately	Low	High	D6.2 documents the required changes to be implemented in Year 3 in Tasks 1.4, 2.4, 3.5, 4.4, and 5.6.
T6.4 Use case evaluation does not achieve sufficiently high user ratings in the evaluation	Moderate	Moderate	D6.2 documents the required changes to be implemented in Year 3 in Tasks 1.4, 2.4, 3.5, 4.4, and 5.6.

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.

With the completion of the software specified in the system architecture (see Deliverable D3.1), and the successful demonstration of the first use case, i.e., the Lab Tour, the work plan has scheduled several tasks (Tasks 1.5, 2.4, 3.6, 4.4, and 5.6, all of which are "Use Case Feedback" tasks) in Year 3 to implement the changes required to improve the performance of the system. These are documented in Deliverable D6.2 Use Case Evaluation. We summarize them in the following.

Task 2.4: Have two variants of the lab tour use case: (a) the robot operates autonomously, without requiring someone to introduce it, and (b) someone introduces Pepper and initiates the tour demo. The former requires the Pepper robot to locate a visitor, wait until mutual gaze is established, and then ask the visitor if she or he would like a tour. The second omits this part, launches directly into the tour, and doesn't require the visitor to follow the robot.

Task 4.4: Ensure that visitor does not have to facilitate interaction by standing is a particular position.

Task 5.6: Minimize pauses or dead zones between different phases of the tour in the behaviorController node, i.e., between each behavior tree action nodes.

Task 5.6: Improve navigation and locomotion in the robotNavigation node, to make it look more purposeful, e.g., using the divide-and-conquer algorithm.

Task 5.6: Implement more comprehensive failure handling in the behaviorController node.

Task 5.6: Query the culture knowledge base in the behaviorController node for the deicticHand keyvalue pair and pass the value to the gestureExecution node.

Task 5.6: Query the culture knowledge base in the behaviorController node for the eyeContactDuration and nodExtentRespect key-value pairs and pass the value to the overtAttention node.

Task 5.6: Implement the receptionist use case.

Task 5.6: Improve the automatic speech recognition, both in terms of reducing the time taken and the reliability.

Task 5.6: Allow more natural spoken interaction by the visitor.

Task 5.6: Adapt seek mode in the overtAttendion node to adhere to cultural norms by dropping the head slightly intermittently to avoid looking at a visitor continuously for long periods. The duration of the mutual gaze before dropping the head and the extent of the drop should be determined by the behaviorController by quering the culture knowledge base using the eyeContactDuration and nodExtentRespect key-value pairs.

Task 5.6 Add or extend a service in the gestureExecution node to use a key-value pair deicticHand LEFT | RIGHT | EITHER.

Task 5.6 Add a key-value pair (deicticHand LEFT | RIGHT | EITHER) to the culture knowledge base.

Tasks 4.4, 5.6 All nodes Implement a means of resetting the node through a service call.

Finally, Task 6.3 will address the user's perception from a social perspective of the manner in which the mission is executed, i.e., an evaluation using RoSAS.

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 was noted in the progress report for the previous period that there had been no formal contact with the University of the Witwatersrand over the past year and that, consequently, CMU-Africa has undertaken five tasks originally assigned to Wits in order to build a complete software system (see Deliverables). This has now risen to seven tasks with the addition of Tasks 6.1 and 6.2. However, as noted above, formal contact with Wits resumed in this period, and the Co-PI from Wits represented the project at the Principal Investigator Meeting in Kigali in June.

CMU-Africa has sufficient funds in Year 3 to continue to employ two, possibly three, research associates to complete the project. The original PI at CMU-Africa, David Vernon, is retiring and is being replaced by Assane Gueye. We anticipate greater collaboration with Wits in this final year of the project.

As a final note, it is important to state that the amount of effort expended in this project far exceeded what was planned or what was funded by Afretec. Over the past two years, some sixteen interns and RAs, most full-time, have worked on the project. The CMU-Africa PI, David Vernon, recorded 1660 hours of effort during the past two years: 528, 215, 268, and 649 in the four six-month reporting periods, respectively. The flexibility afforded by Carnegie Mellon University Africa in allowing the David Vernon to use his Research Professorship Startup Fund to support this project has been instrumental for its success to this point.

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.