ML at the Edge in Francophone Sahel Region: 'Making AI Possible for Mali Cheaply'

Sebastien Diarra[1]
sdiarra@robotsmali.org

Alou Koniba Dembele[1,2]
akad.sciences@gmail.com

Yacouba Traore Ph.D. [2]
email@affiliation.dom

[1]RobotsMali

[2]Ecole Supérieure de Technologie et de Management

ABSTRACT

Researchers in the Sahel region struggle to conduct effective research due primarily to the lack of necessary resources. Recent advancements in Machine Learning have opened up a number of opportunities for research and intelligent solutions for the developing world. Limited resourcefulness by itself is a problem that needs to be resolved, making it an avenue for researchers in the region. The workshop will center around Edge AI as a case study and it aims to attract researchers, aspiring researchers, practitioners, and students together to explore machine learning research, low-resource innovation, as well as low-cost machine learning solutions. Additionally, we expect to pave the way for a culture of scientific research academically and industrially.

CCS CONCEPTS

Computer systems organization~Embedded and cyber-physical systems~Embedded systems~Embedded software

KEYWORDS

Edge AI, Embedded Machine Learning, Edge Computing, TinyML

1. BACKGROUND

In the last few years Artificial Intelligence has been one of the most talked about subjects around the world, with almost daily mentions and publications on the subject. Machine Learning has seen applications virtually in every industry from healthcare, to transportation, to manufacturing. Machine Learning is also part of our day-to-day life, whether it is the smart assistant on your phone, an application automatically tagging people in your virtual albums, or recommending friends on social media. ML solutions are deployed in various environments but the most common deployment is on the cloud. Edge AI is the idea of having ML solutions close to the source of the data, essentially running inferences or occasionally training directly on edge devices. It inherits its name from Edge Computing where an emphasis is put on computing off the cloud. Edge AI brings a unique possibility for Africa, having access to machine learning solutions on cheaper low-powered devices instead of expensive cloud infrastructures offers a wide range of opportunities for researchers, practitioners, students and anyone passionate about the subject to design solutions to problems faced by the continent using ML [5]. We have seen revolutionary

work in the domains such as speech recognition, computer vision, NLP and initiatives like TinyML have even taken the idea of low-powered ML further to the micro-controller / milliwatt (*mW*) level [6]. While most developed regions of the world are actively working on a full range of ML solutions, the Sahel region is relatively trailing behind almost every region, when it comes to AI and ML. Albeit, there are active efforts to promote AI, the field still remains underdeveloped [3][4][7]. A major contributor to the lag in the application and implementation of ML solutions in the region is the cost linked to it[1][2]. We argue that the Sahel region is one of the regions that could benefit the most from ML solutions for its own development. The region is plagued with many problems however limited resourcefulness is at the peak of those problems. From lack of adequate computing infrastructure to steady economies, aspects that are typically overlooked in terms of research. A typical Malian researcher lacks the necessary resources required to run a fully functioning research laboratory. This fact, consequently, leads to a 'Brain Drain', where all the talented researchers conduct their research outside of the region. Given this situation, we propose to seek out modes of conducting ML research in a limited resources environment. This is the workshop's theme '***Making AI possible for Mali Cheaply***'. Cheaply in this context implies 'limited resources'. With this vision, the workshop aims to expose the actors and individuals at the forefront of research in the field of ML, principally Edge AI, internationally and locally. While at the same time shed light on some of the possible research and application domains for Africa, precisely Mali.

2. Workshop Goals / Objectives

This workshop provides a platform for researchers, aspiring ML researchers, engineers, industry leaders, creatives, artists, students, makers, and practitioners from diverse backgrounds to come together and ponder on low-cost ML solutions for Mali and the Sahel region. We aim to have exchanges on techniques, problems, and strategies regarding low-resource situations, and applications of general ML and Edge AI in the country. We expect to address all the viewpoints surrounding the subject, and we do not intend to limit our discussion to Edge AI, an emphasis will be made on 'making cheaper AI solutions'. Accordingly, the objectives of the workshop are:

- Determine the cost/benefits of limited resourcefulness in Mali.
- Identify Edge AI / ML opportunities and downstream applications for the country in Healthcare, Manufacturing, Agriculture, Mining, Security, the arts and so on
- Identify new strategies and techniques for Applied-ML at the Edge that are unique to the region.
- Engage students, researchers, and industry leaders in applied low-resource Machine Learning solutions.
- Ethical / Responsible AI
- Build a community around minimizing the cost of ML solutions for Mali and the Sahel region.

3. Team / Organizers

3.1. Core Team

- **Alou Dembele MSc** is a Mobile Technology Engineer, and an aspiring research engineer in Wireless AI and Edge AI. His research revolves around facilitating education using AI. He is a strong proponent of STEM education and Robotics. Leading and promoting the development of Machine Learning based solutions among Youth.

- **Sebastien Diarra** is currently working as ML Research Lead at RobotsMali, his work focuses on Machine Translation, Natural Language Understanding, and Automatic Speech Recognition for low-resource languages principally Malian languages. The work encompasses the application of ML solutions in Mali, especially on edge devices.
- **Yacouba Traore Ph.D.** He holds a Ph.D. In computer engineering, an expert in Education, and he is is a progressive teacher, versed in multiple natural languages. He is a researcher, head of the science and technology department, and head of the Quality Assurance Unit at ESTM. He also dabbles in entrepreneurship. He is the owner of a primary school named *e-Bahina* and an IT Start Up named *EIM S.A.R.L.*

3.2. Student Support Team (Artificial Minds Club)

- **Yasmina Alidou** is a second-year Engineering student at ITMA in Bamako with strong interests in Computer Science and AI. Her goals are to learn as much as she can on the subject to be able to create something useful for humanity in the future. She is a Co-Founder (Lead) of Artificial Minds.
- **Sokona Coulibaly** is a second-year Computer Engineering and Telecommunications student at Université Privée Mary Saint Claire in Bamako. She is an enthusiastic learner and tutors other students. She is strongly interested in Artificial Intelligence and plans to pursue a career in the Field. She aims to inspire girls to pursue careers in science and technology.
- **Yacouba Diarra** is a second-year Computer Science student at ITMA in Bamako with a strong interest in Machine Learning and Data Science. He is actively learning, presently learning Machine Learning through Machine Translation, and Computer Vision. He is an astronomy enthusiast. He is also a Co-Founder of Artificial Minds.
- **Panga Azazia Kamate** is a second-year Computer Science student at IPSMART in Bamako. He is passionate about Machine Learning and Computer Systems Programming. He is an avid ROS enthusiast.
- **Mamadou K. Keita** is an undergraduate student researcher at RobotsMali and African Development University in Niamey. His research is concentrated on autonomous systems and intelligent systems. He has multiple publications under his belt on medium. He is also an entrepreneur, and the founder of the 27group.
- **Abdoulaye Sako** is currently a second-year Engineering student at ITMA in Bamako. He is passionate about Robotics and Artificial Intelligence. He aspires to become a Machine Learning Research Engineer to help people and the community with his work. He is a Co-Founder of Artificial Minds.

4. Pre-workshop

4.1. Weekly Meeting

We will hold weekly information and question-and-answer meetings online for the general public starting on **5/6th** and ending on **7/2nd** the last Sunday before the workshop. The objective of these meetings is to inform prospective participants to better understand the workshop and better

prepare for it. We hope to address all issues and concerns prospective attendees will have. We will have sessions on the application procedure and some complex topics such as *Introduction to overleaf and LaTex*, *the templates*, *A primer on Edge AI*, *and Embedded Machine Learning.*

4.2. Website

We will create a website to introduce the subject of the workshop, in addition, we will have all the necessary information about the application for attendance process, the calendar, the competition, the call for papers/posters, and contact information posted on the website: https://edgemali.github.io/2023. The website will update accordingly to inform the participants and prospective participants of the event. After the workshop, we will use the website to publish all of the papers and work showcased as well as all the solutions presented for the competition.

4.3. Recruitment

We aim to recruit Malian researchers, students, practitioners, decision-makers and aspiring researchers from diverse fields varying from machine learning to engineering to arts and literature locally and living abroad with the goal of having the most diverse group of individuals at the workshop come and collectively think about Edge AI and Low-cost AI and their applications in Mali. We will recruit participants via a number of channels including but not limited to social media campaigns using Twitter, WhatsApp, and Facebook as well as mailing lists, ***word of mouth*** will be our primary channel locally, and posting fliers at major universities in the country. We will have three modes of participation, general application, competition, and the call for papers.

4.4. Application

We will have a public application form for participants to apply for attendance for the workshop. The form will be open for a month, starting on **May 1st** and closing on **May 31st at 11:59 pm AoE.** Attendance will be free for students and a **$25** fee for professionals for badges and t-shirts. The number of attendees will be limited to 100 people, 75 students / 25 professionals.

4.5. Workshop Mode

The workshop will be an in-person event in Bambara-English-French, a trilingual activity based on the featured speaker's request. We will make sure to have synchronous online sessions available (with Zoom, Meet, or Teams) for those who are unable to attend the event physically. Based on registration, extra accommodation will be made available for non-able individuals.

4.6. Venue / Facilities and Materials

The exact venue is **TBD** at a later date. The venue must be able to have a large room (amphitheater) capable of holding 100+ attendees. A hall will be needed for the sponsor booths and project display. A refreshment room and/or cafeteria will be needed for coffee breaks and lunch. Several (at least 3) rooms will be needed to host practicals and tutorials. A/V capabilities and installations should be made available for all the rooms.

5. Workshop

The workshop is expected to be held during two days, starting on **July 7th** and closing on **July 8th 2023**. A tentative calendar is shown in Appendix A.

6. Post-Workshop

The discussions and the materials used and presented at the workshop including the papers and projects will be hosted on the website. We will post the different hypotheses and potential research questions brought up on different platforms to encourage research and development. More importantly, we plan to create a community of participants to continue the work on cheaper AI solutions for the region. Selected papers will be proposed for Deep Learning Indaba[1] research in Africa Day poster sessions.

7. Competition

7.1. Background

In the francophone-Sahel region we are confronted with many problems among which are: Illiteracy, Internal Conflicts, Poverty, Climate change, Lack of Opportunities (Employability), Corruption, **and** No reliable information technology infrastructure.

Deep Learning is dominating all aspects of life in the developed world. From self-driving cars to automated diagnosis systems. As humans, we were able to resolve many complex and challenging problems with smart and intelligent agents. The most recent advances in DL **have** led to Large Language Models, which are the backend for **Chatbots**, as well as Generative AI, and Reinforcement Learning. This only cemented the idea that **DL-based** solutions are pertinent in all industries. Although these models are highly accurate in most developed settings. They are expensive and **highly resource-consuming** to train and deploy; often requiring months of intense computation and highly fault-tolerant infrastructure.

We here in Mali do not have this advantage. Where even having constant and stable electricity is a luxury. On top of all of that many of the most advanced machine learning models are not trained with **the** contextual nature of reality in these regions. A Deep Learning model trained to help a farmer in China would be difficult to adapt to the needs of a Malian farmer. Often requiring the same amount of resources used for the initial training. This situation applies virtually in every ML **domain**, from Machine Translation to Speech Recognition.

7.2. Challenge

For this competition, you are tasked to solve a real problem faced by the country using ML. Challengers are encouraged to work on any problem domain that they deem critical for the development of the country/region.

Solutions can look at algorithmic efficiency and optimization using a theoretical approach, or can work on actual products for marketability. Listed below are some example projects and domains for inspiration:

- Autonomous Systems, Robotics, and Manufacturing, Logistics
- Efficient Energy Distribution to minimize **'Blackouts'**
- Healthcare and Intelligent trial drugs synthesizers i.e for **Malaria**
- Predicting Migratory Patterns for the Armed Terrorist Groups in the Sahel
- Sustainable Communities and Infrastructures
- Retail Management
- Automatic speech translator for local languages
- Smart & Intelligent Agriculture

For your solution, you should take the 'low-cost' aspect as an integral idea of the solution. Your solution should focus on Compression and Quantization, and considerably take them into account

in your design. You will be judged by the efficiency of the solution in the most extreme use cases. Challengers are encouraged to look for alternative approaches to reduce the cost of traditional Machine Learning approaches in terms of complexity and the computational resources required to train and run inference on proposed systems.

***Note** that you do not need a complete solution. Prototypes are accepted.*

7.3. Criteria

Due to the fact that we have a number of limited seats at the workshop, we will have a selection phase where a limited number of teams will be selected to compete for the prize. The participation criteria for the competition are the following: Solution is made in Mali or made for Mali Teams can have 2 to 5 members, and preferably at least one member of the team must be Malian. The solution must be ML / AI-centric, with accompanying benchmarks.

Join our weekly Office Hour to learn more about the competition.

7.4. Program

Dates	Activity
05/01/2023	Application Opens
5/31/2023 @ 11:59 pm AoE	Application Closes
06/10/2023	Selection Announcement / Results
07/01/2023	Final report and results Submission

7.5 Prizes

*The winning team will be awarded a monetary prize the exact sum is **TBA**, and the other teams can benefit from other rewards such as mentorship, or material supports.*

8. Call for Papers / Posters

8.1. Overview

The scientific culture in the country is underdeveloped, with minimal publications attributed to Malian authors and researchers. We would like to use this forum to bring together and encourage aspiring researchers and researchers from diverse fields to investigate various subjects related to machine learning or work on projects for local downstream applications. This call is not limited to academic research, industry solutions worthy of highlights should submit as well. Although we are not a big research venue, we encourage both Malians abroad and local researchers to submit work, to be presented and showcased. Candidates have the possibility to submit a full research paper (completed or preliminary manuscripts), or position paper responding to one or more of the underlying themes of the workshop.

- How to make ML research cheaper for communities with limited resources?
- What are strategies and techniques to overcome the limitation in terms of resources?
- Edge AI / ML for the under-served communities
- Collaborative ML and Shared resources
- Low-cost efficient Machine Learning Algorithms
- Embedded Machine Learning

For the position papers you are not limited to the points highlighted you can respond to your own questions. Additionally, you *can also join our weekly office hours if you are interested in learning more about the call.*

8.2. Dates

- Submission Deadline: May 31th, 2023 **@ 11:59 pm AoE**
- Notification Acceptance: June 3rd, 2023
- Camera-Ready / Posters Due: June 23rd 2023

8.3. Submission

Research Paper	Position Paper
French / English	French / English / Bambara
6 – 14 pages (exclude references)	2 – 8 pages (exclude references)

Anonymous Submission Template

ACM Template

Submit to: research@robotsmali.org

Acknowledgments

TODO: Grants, Sponsors, Reviewers

References

[1] Cisse, I. (2023a). *Adoption du cloud en Afrique : exploiter le potentiel pour la croissance économique et le développement | Ibraci Links*. Ibracilinks.com; Ibraci Links. https://ibracilinks.com/blog/adoption-du-cloud-en-afrique-exploiter-le-potentiel-pour-la-croissance-conomique-et-le-dveloppement

[2] Cisse, I. (2023b). *L'avenir de l'industrie africaine du cloud : Opportunités et Défis avec Google, AWS et Microsoft | Ibraci Links*. Ibracilinks.com; Ibraci Links. https://ibracilinks.com/blog/lavenir-de-lindustrie-africaine-du-cloud-opportunits-et-dfis-avec-google-aws-et-microsoft

[3] Diarra, H. S., & Leventhal, M. (2020). *Developing Machine Learning Competence in Africa in the Francophone Sahel Region enonymous uthors per under douleElind review*. ICLR. https://pml4dc.github.io/iclr2020/papers/PML4DC2020_38.pdf

[4] Leventhal, M., Tapo, A., Zampieri, M., Homan, C., & Luger, S. (2020). *ASSESSING HUMAN TRANSLATIONS FROM FRENCH TO BAMBARA FOR MACHINE LEARNING: A PILOT STUDY*. ICLR. https://arxiv.org/pdf/2004.00068.pdf

[5] Ooko, S. O., Muyonga Ogore, M., Nsenga, J., & Zennaro, M. (2021, December 1). *TinyML in Africa: Opportunities and Challenges*. IEEE Xplore. https://doi.org/10.1109/GCWkshps52748.2021.9682107

[6] Situnayake, D., & Plunkett, J. (2023). *AI at the Edge*. O'Reilly Media.

[7] Zaid, Z. (2023). *Jacqueline Konaté : "Au Mali, il reste beaucoup à faire pour développer l'IA."* DZ CHARIKATI; DZ CHARIKATI. https://dzcharikati.net/jacqueline-konate-au-mali-il-reste-beaucoup-a-faire-pour-developper-lia/

[8] Zennaro, M., Plancher, B., & Reddi, J. (2022, May). *TinyML: Applied AI for development*. https://sdgs.un.org/sites/default/files/2022-05/2.1.3-9-Zennaro-TinyML.pdf

APPENDICES

A. Tentative Calendar

a. Day I

Program (Day I)	Activity		Description
09:00 am - 09:30 am	Welcome Note / Ice Breaker		Introductory notes, and Ice breaking activities
09:30 am - 10:15 am	KEYNOTE I		Domain Expert
10:15 am - 10:45 am	**Coffee BREAK**		
10:45 am - 12:00 pm	Sponsor Slot	Collective Brainstorming (start.) EdgeAI (ML) for Development thematic discussions	Present Sponsor materials and booths, live interviews
	Paper / Poster Preview		
12:00 pm - 01:00 pm	Competition Solutions Preview		Brain storming on ML solutions in Mali, and discussions with Industry leaders on domain applicability, problems faced.
01:00 pm - 01:30 pm	**LUNCH**		
01:30 pm - 02:00 pm	Practicals (concurrently): EdgeAI (EI, AIMET, ONNX, TF Lite) BCI (EEG) SNN (Spinking NN) Sponsored Activities….	Collective Brainstorming (continue.) EdgeAI (ML) for Development thematic discussions	Practicals and Tutorials
02:00 pm - 03:00 pm			
03:00 pm - 04:30 pm			Brain storming on ML solutions in Mali, and discussions with Industry leaders on domain applicability, problems faced.
04:30 pm - 05:00 pm	**Coffee BREAK**		
05:00 pm - 05:45 pm	Mentors presentation, Q/A, Reflective Discussions		Mentor assignment. Q/A
05:45 pm - 06:00 pm	Day Closing note		Closing notes

b. Day II

Program (Day II)	Activity			Description
09:30 am - 10:15 am	Keynote II / Sponsor Activity			Domain Experts / Sponsored Discussion
	Light Coffee Refreshments			
10:15 am - 11:00 am	Poster Sessions	Lightning Talks	Competition Juy	Lightning Talks, poster

11:00 am - 12:00 pm				presentations, and competition solution presentations
12:00 pm - 12:30 pm				
12:30 pm - 01:00 pm	**LUNCH**			
01:00 pm - 02:00 pm	Presentation (Papers / Discussions)		Sponsor SLOT	Discussions and papers presentations
02:00 pm - 03:00 pm				
03:00 pm - 04:00 pm				
04:00 pm - 04:30 pm	**Coffee Break**			
04:30 pm - 05:00 pm	Mentorships / Chat with domain experts / Industry leaders			Mentorship opportunities for Students
05:00 pm - 05:30 pm				
05:30 pm - 06:30 pm	Closing Keynote, closing note, Awards			Closing activities
06:30 pm - EVENING	**Waterfront Networking Event**			