Carnegie Mellon University Africa
Certificate I: Understanding AI and Machine Learning in Africa

Course AIML02: AI and Machine Learning in Africa

Module 4: Deployment of AI and Machine Learning in Africa
Lecture 1: Machine Learning for the Developing World

Welcome to Module 4 of AI and Machine Learning in Africa, a course which provides an overview of the relevance of AI and machine learning to Africa and their potential to solve economic and social problems.

In Module 4, we examine the factors that must be considered when deploying AI in Africa.

There are two lectures in this module.

In the first lecture, we will explore the field of machine learning for the developing world, in general. We will do so by summarizing the material in an article by De-Arteago et al. (2018).

In the second lecture, we will zone in on what is necessary for successful deployment in Africa, specifically. Here we will summarize the key points of an article by Gwagwa et al., (2020).

In this lecture, we define machine learning for the developing world (ML4D). We introduce five pillars of development and give examples of machine learning in each pillar.

We then revisit a recurring theme of this course: the importance of factoring in local context when analysing problems and devising solutions to these problems.

We provide an overview of the road map for ML4D introduced by De-Arteaga et al. (2018). We highlight the opportunities identified by De-Arteaga et al., (2018) for advancing machine learning through ML4D.

We finish up by summarizing what we have covered and identifying the articles that you should read to consolidate what you have learned.

We have five learning objectives, so that, after studying the material covered in this lecture, you should be able to do the following.

1. Define machine learning for the developing world (ML4D), differentiate it from traditional machine learning, and identify its four core attributes.

2. Identify the five pillars of development.

3. Explain the best practices for ensuring that ML4D projects are relevant.

4. Explain a proposed roadmap for research in ML4D.

5. Identify opportunities that ML4D affords for the development of the discipline of machine learning.

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Slide 2 Machine Learning for the Developing World has four key properties:

(1) Applications and data are geographically constrained to developing countries.

(2) The problem concerns a critical development area for the region of interest.

(3) The problem, or a contextual element of it, means that existing or plausible solutions in developed regions are not viable. The proposed solution effectively addresses these differences.

(4) The solution substantially use\s machine learning as an integral element.

Properties 1 and 2 mean that we only consider issues that are exclusive to the developing world, either because the problem only exists in the developing world or because there are local contextual issues that mean the solutions are fundamentally different in these areas.

The third property highlights the consequence of this: the need for solutions to be locally viable.

Slide 3 This calls to mind something we touched on the previous lecture.

In the words of the authors of the article we are studying

"Successful solutions in developed nations may not succeed in developing ones".

Slide 4 Machine learning for development may involve novel statistical or machine learning methodology.

The methodology might involve new theories or techniques, it doesn't have to.

The application of existing methods in novel ways may often be the appropriate ML4D approach.

The phrase "in novel ways" is important. This means that ML4D is not simply applying ML to developing world datasets.

ML4D is grounded in the local context.

This is one of the recurring themes of this course.

Slide 5 We consider five pillars of development and, in each one, we will give examples of how machine learning can be used in developing countries.

Slide 6 The five pillars are

The health pillar
The institutional pillar
The economic pillar
The social pillar
The environment pillar

Slide 7 In the health pillar, examples include

- Automated diagnostic systems in remote areas and urban hospitals for a plethora of diseases from dengue fever to cataracts.

- Anomaly detection to identify data-entry errors in medical records. This is important because sustainable medical treatment depends on high-quality medical data.

- Optimizing travel routes for health workers.

- Tracking infants using novel fingerprint technology to ensure they are getting the proper vaccinations.

- Early detection of outbreaks of disease, sometimes using non-traditional alternative data sources such as social media activity and phone records.

Please refer to the original article by De-Arteaga and colleagues (2018) for references to paper describing each of these examples.

Slide 8 In the institutional pillar, examples include

- Crisis mapping, that is providing analysis of violence, protests, or environmental disasters over time and across geographical regions.
- Predicting violence in urban environments.
- Detecting patterns of sexual violence.
- Detecting patterns of human rights violations.
- Assessing risk of fraud and collusion in international development contracts.
- Detecting electoral fraud.

Slide 9 In the economic pillar, examples include

- Network analysis to understand how a country's products and exports impact their capability for future growth.
- Predicting default on cell phone debts.
- Predicting famine and poverty using satellite images.
- Detecting illegal mining activity using satellite images.

Slide 10 In the social pillar, examples include

- Resource allocation based on analysis of population mobility using cell phone data.
- Intelligent tutoring systems for low-cost, personalized education.
- Internet access using speech recognition and generation for communities that speak niche languages.

Slide 11 In the environment pillar, examples of the use of machine learning typically address the study and mitigation of natural disasters,

which have a disproportionate impact on the developing world compared to the developed world.

For example,

- The study of flooding and landslides.
- The detection and prediction of seismic events.
- The analysis of land use and availability of agricultural land.
- Analysis of migration patterns of herders.

Slide 12 It is essential for researchers to consider the local context of their project in order to ensure proper alignment between development needs and the project's technological and institutional objectives.

For example, if the goal is to inform policy, the technical methodology should provide results that can actually be used by policy makers, i.e., that the policies are feasible.

The results of a study of student needs that indicated 70% of students required interventions are of little use to schools that already have a shortage of teachers.

Slide 13 It is also essential to take into account infrastructure constraints,

such as computational capacity and the need to travel long distances for repairs,

or whether people have access to smart phones or feature phones

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Slide 14 Machine learning allows computers to perform tasks that could previously only be achieved by highly skilled experts.

Consequently, machines can potentially perform jobs that are fundamental for society and difficult to fill currently.

For example, augmenting and supporting human teachers
would help increase literacy and improve STEM skills,
thereby facilitating development.

Slide 15 A three-step road map to illustrate how ML4D can be used to advance global development goals

Step 1: Improve the reliability of data

Step 2: Provide direct solutions and deployed systems. In other words, build systems that have a positive impact on people's lives, such as those we explored in the case studies in Module 2.

Step 3: Inform policy and decision makers; recall the case study on socioeconomics in Module 2, Lecture 6.

Slide 16 The limitations and difficulties of successfully deploying ML technologies in the developing world are often highlighted.

These are only true because the technology has been built assuming the conditions of developed countries.

Thus, current ML tools encode the infrastructure and cultural conditions of developed regions.

It should come as no surprise that the same tools may not work as effectively when such criteria are no longer met.

Slide 17 Instead of thinking of these conditions as roadblocks stopping the successful deployment of ML,

Think of them as research opportunities to advance ML by weakening or eliminating these assumptions.

For example, poor data quality is often seen as a problem with ML4D.

But viewed another way, it becomes a valid research question:

how can multiple incomplete, biased data sets be combined so that the bias is eliminated?

For example, limited computing resources often seen as a problem with ML4D.

But viewed another way, it too becomes a valid research question:

how can students who share a computer in classrooms use active learning to maximize the benefits?

Slide 18 While novel methodological research is not a necessary element of ML4D

– it's enough to do new things with existing tools and techniques –

there are, nevertheless, many areas of machine learning that can yield novel research motivated by ML4D.

These opportunities are shown in the boxes under the roadmap.

They are

[click]

Learning with small data,
to compensate for the lack of digitized historical records as well as limited capacity to acquire and store data.

[click]

Learning from multiple messy datasets,
as mentioned already, to compensate for difficulties in creating large, clean data sets.

[click]

Intelligent data acquisition,
to compensate for limited resources and infrastructure and actively select the most informative data.

[click]

Transfer learning for low-resource languages,
to ensure inclusion of all communities in Africa.

[click]

Learning with limited memory and computation
is essential where computational resources are restricted.

[click]

Intelligent compression algorithms,
to compensate for limited bandwidth, especially for advanced technologies such as telemedicine.

[click]

Decision support systems,
for example, in healthcare and government, especially where medical and administrative expertise is in short supply.

To summarize,

1. Machine Learning for the Developing World, or ML4D for short, is not simply the application of ML to developing world datasets.

2. ML4D is grounded in the local context.

3. There are five pillars of development: health, institutional, economic, social, and environment pillars, all of which can benefit from ML4D.

4. ML4D doesn't necessarily involve the development of new techniques: the application of existing techniques in novel ways may often be appropriate.

5. However, research motivated by ML4D in many areas of machine learning can yield novel results.

Here is the article on which this lecture is based. Please take the time to read it and then review this lecture again.

De-Arteaga, M., Herlands, W., Neill, D. B. and Dubrawski, A. (2018). Machine Learning for the Developing World, Association for Computing Machinery, Vol. 9, No. 2, pp. 1-14. https://www.ri.cmu.edu/wp-content/uploads/2020/05/3210548.pdf