

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

Course AIML02: AI and Machine Learning in Africa

Module 1: The Potential of AI and Machine Learning in Africa

Lecture 1: Realizing the Potential of AI in Africa

Welcome to 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.

Before we get started on the first lecture, let's look at the structure of the course.

The material is based on fourteen articles.

In Module 1, two articles address the potential of AI and machine learning in Africa.

Module 2 features six case study articles on the application of AI and machine learning in Africa. Since these articles can be quite technical, the lecture abstracts the key elements of the article and adds, where necessary, supporting explanations.

The four articles in Module 3 focus on AI business strategy.

Finally, in Module 4, two articles examine some factors that must be considered if you are to be successful when deploying AI in Africa.

Here is the overall structure of the course. The references are provided at the end.

**Module 1: The Potential of AI and Machine Learning in Africa**

Lecture 1.1: Realizing the Potential of AI in Africa (Delmus Alupo et al., 2022)

Lecture 1.2: Computational Sustainability and Artificial Intelligence in the Developing World (Quinn et al., 2014)

**Module 2: Application Case Studies**

Lecture 2.1: Healthcare (Onu et al., 2017; Onu et al., 2019)

Lecture 2.2: Logistics (Ackerman and Koziol, 2019)

Lecture 2.3: Agriculture (Quinn, 2013)

Lecture 2.4: E-Commerce (Uwizera et al., 2020)

Lecture 2.5: Socioeconomics (Yeh et al., 2020)

Lecture 2.6: Conservation (Xu et al., 2020)

### **Module 3: AI Business Strategy**

Lecture 3.1: Artificial Intelligence for the Real World (Davenport and Ronanki, 2019)

Lecture 3.2: How to Choose Your First AI Project (Ng, 2019)

Lecture 3.3: Collaborative Intelligence: Humans and AI Are Joining Forces  
(Wilson and Daugherty, 2019)

Lecture 3.4: The Future of AI Will Be About Less Data, Not More  
(Wilson, Daugherty, and Davenport, 2019)

### **Module 4: Deployment of AI and Machine Learning in Africa**

Lecture 4.1: Machine learning for the developing world (De-Arteaga et al., 2018)

Lecture 4.2: AI deployment in Africa: benefits, challenges, and policy dimensions  
(Gwagwa et al., 2020)

In the first lecture, we revisit a prediction by J. C. R. Licklider in 1960 about the way the relationship between humans and computer technology would evolve. We encountered this prediction already in the first lecture of AIML01 Artificial Intelligence – Past, Present, and Future. We will explain how this is being realized today by AI and machine learning in what is known as the fourth industrial revolution during what has been dubbed "The Cognitive Era". In doing so, we highlight two centers for the fourth industrial revolution in Africa.

We explore the relationship between invention and adoption, and the way that adoption depends on sociocultural issues, including trust, and we highlight the implications for the success of AI and machine learning in Africa.

We preview some examples of the use of AI in Africa, specifically the case studies that form Module 2 of this course.

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

We begin, though, with a short reprise of the first few slides of Lecture 1, Module 1, AIML01 AI – Past, Present, and Future.

After watching and listening to this lecture, and studying the slides that follow, you should read the two articles recommended at the end, take notes, and then go through the lecture again to consolidate the messages in the articles. At that point, you will have achieved the following four learning objectives and to you will be able to do the following.

1. Explain how AI amplifies and extends human cognitive abilities.
2. Explain why AI forms the foundation of the Fourth Industrial Revolution.
3. Explain why the benefits of AI depend on innovation, and hence on adoption and trust.
4. Identify several examples of the use of AI and machine learning in Africa.

Slide 1 Welcome to 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 the first lecture of Module 1, we will explore the key messages in an article entitled "Realizing the Potential of AI in Africa", written by two alumni of CMU-Africa, Charity Delmus Alupo and Daniel Omeza, and a member of the faculty, David Vernon. We referred to this article already in course AIML01.

It addresses the issues that arise in realizing that potential, distinguishing between the processes of technological invention, innovation, and adoption, and the latter's dependence on socio-cultural factors, including trust.

After watching and listening to this lecture, you should read the article, take notes, and then go through this lecture again to consolidate the messages in the article.

Slide 2 Humans have always used tools to augment & amplify their physical capabilities, Whether they are for cutting

Slide 3 or digging.

Slide 4 The computer extended this to mental work, mainly as a tool for greatly increasing the speed of processing

Slide 5 However, the developments in artificial intelligence over the past sixty-five years,

have ushered in what John Kelly at IBM refers to as the cognitive era, superseding the tabulating era and the on-going programming era.

Slide 6 Recall from the first lecture in course AML01, that, in 1960, J. C. R. Licklider predicted a symbiotic partnership between humans and computers.

Symbiosis refers to a situation where two distinct species cooperate, or work together, closely in a relationship that achieve what neither on their own could achieve.

Licklider said this relationship would occur between men and computers.

(Today, we try to avoid such gender bias and we would refer to a relationship between humans and computers.)

Slide 7 This symbiotic partnership between humans and computers will perform intellectual operations much more effectively than humans can perform them on their own.

Slide 8 Today, this symbiotic partnership is being realized through AI and machine learning

AI both amplifies and augments or extends human cognitive abilities, improving our existing skills and also giving us new ones.

Thus, we can do what we used to do, but now we can do it much more quickly, much more efficiently, and much more effectively.

We can also solve problems that we simply weren't able to solve before.

Slide 9 Today, we are in the middle of another industrial revolution - the fourth industrial revolution - and AI is one of its main foundations.

The fourth industrial revolution – sometimes referred to as 4IR or Industry 4.0 – involves the fusion – the tight integration – of physical, digital, and biological technologies.

These are often referred to as cyber-physical systems. Think of smart, wearable devices that interface directly with our sensorimotor or brain function and that assist us in our daily lives.

These are powered by AI and machine learning.

And they work by being able to communicate everywhere with other devices and data sources.

Slide 10 The Fourth Industrial Revolution represents a fundamental change in the ways that we live and work.

It is a new chapter in human development, ... merging the physical, digital, and biological worlds and fusing technologies in ways that create both promise and peril.

Slide 11 According to many people, the fourth industrial revolution is irreversibly altering how humans live, work, and relate to one another.

Here is what the World Economic Forum has to say about the matter.

If you haven't already listened to it when you studied for for AIML01, please listen to it after this lecture.

Slide 12 The World Economic Forum enables a fast-growing network of Centres for the Fourth Industrial Revolution

to help connect technology policy experts and stakeholders

across 15 advanced and emerging economies

representing 40% of global GDP and 30% of the global population

There is a centre in Rwanda and one in South Africa.

Slide 13 One of the biggest challenges we face is make sure we harness AI within an ethical framework.

Meaning that the economic benefits and social advances are achieved for everyone, everywhere.

Or, as the World Economic Forum puts it, "in ways that create a more inclusive, human-centred global economy."

Slide 14 For everyone, everywhere ... that includes Africa.

The Fourth Industrial Revolution and the digital transformation of Africa has the potential to greatly increase the rate of growth and advancement in many sectors of life and industry.

The authors of this article put it like this

"The Fourth Industrial Revolution ... has ushered in a new era of economic disruption with uncertain socio-economic consequences for Africa."

So, how can we mitigate the risks associated with this uncertainty to ensure that Africa benefits from the fourth industrial revolution?

This is the question we consider next.

Slide 15 There is a difference between creativity, invention, and innovation.

Slide 16 Creativity can lead to the invention of a novel idea or artefact.

Slide 17 Innovation brings creativity & inventions into wider use:

the diffusion of that invention and its widespread adoption,

leading to substantial social change in the practices of a community of people.

Slide 18 Rose frames this succinctly in a formula:

“innovation = invention + exploitation + diffusion”,

where the innovation is commercially developed and exploited, and, significantly, adopted in a wider community of users.

Slide 19 Successful innovation also depends on infrastructure, an often-unnoticed precondition for technology innovation.

There are two forms of infrastructure, the physical and the social.

The physical infrastructure might include the availability of electrical power, communications networks, or internet connectivity, something that is taken for granted in developed countries, but which cannot always be assumed in developing countries.

Of equal importance is the social infrastructure which includes the social conventions that govern people's behavior and the practices they find acceptable and unacceptable.

Crucially, social infrastructure includes trust and people's sense of what is trustworthy.

Social infrastructure heavily impacts on whether or not an invention is adopted and becomes an innovation that can yield benefits for the local community.

Slide 20 Trust can be defined as the expectation that a service will be provided or a commitment will be fulfilled

Slide 21 Expectations depend on many things and are grounded in the socio-cultural experience of those whose trust is required.

Slide 22 There are many factors at play in the development of trust, including individual, organizational, and cultural context.

Culture is "a set of social norms and expectations that reflect shared educational and life experiences associated with national differences or distinct cohorts of workers".

Slide 23 These factors have a major bearing on how technology, generally, and information technology, powered by AI, in particular, can support an individual or a local community in Africa and whether or not that support, no matter how well intended, will be accepted, trusted, and adopted.

- Slide 24 Put another way, parachuting in solutions developed in a different, external sociocultural context may not work.
- Innovation needs to be in the hands of those who understand the sociocultural factors that impact on trust,
- an understanding of which is essential for adoption and the realization of the benefits of the technological invention.
- Slide 25 In other words, as Michel Bézy puts it, it is imperative to “develop the African innovation market where new ICT solutions that are adapted to Africa’s environment and needs will be developed by Africans for Africa”
- Slide 26 Moustapha Cisse, head and co-founder of the Google AI Research Lab in Accra, Ghana, and Professor of Machine Learning at the African Institute of Mathematical Sciences, makes a compelling argument for developing AI here in Africa.
- Slide 27 He argues that "AI ... offers a unique chance to improve lives without opening up and exacerbating global inequalities”.
- Slide 28 and that "That will require widening of the locations where AI is done."
- Slide 29 That "the vast majority of experts are in North America, Europe and Asia. Africa, in particular, is barely represented."
- Slide 30 He argues that "such lack of diversity can entrench unintended algorithmic biases and build discrimination into AI products."
- Slide 31 Finally, he argues that ""Fewer African AI researchers and engineers means fewer opportunities to use AI to improve the lives of Africans."
- Slide 32 Happily, this is changing fast.  
[click]  
Why?  
[click]  
Because of the accelerating rate of education.  
[click]  
And because you are here, taking this course.



Slide 33 Let's finish up with brief previews of the six case studies in Module 2.

These are good examples of AI and machine learning in Africa, each drawn from a different sector:

Healthcare  
Logistics  
Agriculture  
E-Commerce  
Socioeconomics  
Conservation

Slide 34 The case study on healthcare looks at a mobile application to detect respiratory distress, specifically a condition referred to as asphyxia, in newborn babies. It looks at the development path from initial idea to clinical studies in Nigeria, and walks through two approaches to detection, one based on traditional machine learning, and one based on deep learning.

Slide 35 The case study on logistics documents the use of drones to deliver blood to rural clinics and hospitals in Rwanda.

Slide 36 The case study on agriculture examines image processing for monitoring crop disease in Uganda, using machine learning to create maps showing the likely incidence of disease.

Slide 37 The case study on e-commerce looks at the development of a mobile application to verify the identity of customers and clients using face recognition. It differs from other approaches in that it specifically targets Africa faces and used a deep learning neural network that is customized using transfer learning on a proprietary African dataset.

Slide38 The case study on socioeconomics demonstrates how machine learning, specifically deep learning, can be used to predict asset wealth across approximately 20,000 African villages when trained with data in the form of satellites images.

Slide 39 The case study on conservation uses machine learning, this time probabilistic machine learning, to identify areas of high risk of poaching in Uganda and compute optimal patrol routes.

To summarize:

1. We are currently in the cognitive era, in which humans and computers are forming a symbiotic partnership, powered by AI and machine learning.
2. This era is being accompanied by the Fourth Industrial Revolution, with centres in Rwanda and South Africa.
3. Africa can benefit greatly from the Fourth Industrial Revolution through socioculturally-sensitive innovation.
4. Innovation involves invention, exploitation, and diffusion, but it depends on adoption and trust.
5. The means that we must develop solutions that are adapted to Africa's environment, and they need to be developed by Africans for Africa.

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

Delmus Alupo, C., Omeiza, D., and Vernon, D. (2022) "Realizing the Potential of AI in Africa – It All Turns on Trust", in *Towards Trustworthy Artificial Intelligence Systems*, M. I. Aldinhas Ferreira, O. Tokhi (Eds.), Intelligent Systems, Control and Automation: Science and Engineering. Springer.  
[http://vernon.eu/publications/2023\\_Delmus\\_Alupo\\_et\\_al.pdf](http://vernon.eu/publications/2023_Delmus_Alupo_et_al.pdf)

Here are the references cited to support the main points in what we covered in this lecture. They include the other thirteen articles we'll study in this course.

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Video: How Rwanda Built a Drone Delivery Service (highlighting the engineering accomplishments of the delivery service).  
<https://www.youtube.com/watch?v=jEbRVNxL44c>

Video: Data-driven drones deliver lifesaving medical aid around the world: Databricks customer story on Zipline.  
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