# Artificial Intelligence and Machine Learning enhancing South African SMME: Indigenous knowledge as a common factor for successful implementation and adoption of AI and ML enabled ICT solutions

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**Abstract.** Endogenous knowledge that forms the basis for experience of people from developing world is important for understanding their adoption and use of ICT applications. A local theory that helps to explain the endogenous knowledge has to be developed in order to predict the successful adoption of the ICT applications. Disciplined imagination together with scientific simulation can to be used to investigate the causal role endogenous knowledge plays in the adoption and use of ICT application. With the understanding of the endogenous knowledge, opportunities that are offer by Artificial Intelligence and Machine Learning based 4th Generation Industrial Revolution can exploited to the benefit of the South African SMMEs.

**Keywords:** Artificial Intelligence, Machine Learning, Endogenous Knowledge, Imagination, Scientific Modeling.

# 1 ICT Application, Artificial Intelligence and Machine Learning

## 1.1 Increase in the processing power and performance of computer systems

ICT has been a source of economic growth for the developed world in the information age (Vu 2011). The exponential growth in computer performance has added further impetus to the capability of ICT to perform much more tasks than before. This follows Gordon Moore's law, one of the founders of Intel, that transistor count on integrated circuits will double roughly every 18-24 months (Moore 1965; Moore 1975), which has resulted in the growth of computer processing speed, technology storage memory, and great reduction in the cost of computers and storage disk.

## 1.2 Increased computer performance

This increased computer performance has enabled computers to, efficiently and effectively, process complex artificial intelligence and machine learning algorithm which was impractical previously (Hilbert 2016). These algorithm have unprecedented capability of performing cognitive task with far ranging impact on the ways certain function are performed, whereby jobs that could traditionally only be performed by human could now be performed by computers (Autor 2015). Also, with the increase in processing speed and technology storage memory, complemented with the advent of internet network which resulted in the proliferation of massive amount of data, Big Data analytics have become proficient in identifying unique pattern in the data to discover new objects, predict the occurrence of certain phenomena, using proxy data instead of statistical data, which was difficult with traditional statistical approaches (Hilbert 2016). This has added further impetus on the economy of the developed world.

## 1.3 First Order and Second Order Digital Divide

The benefit that accrued from ICT have not translated directly to the benefit of the developing world (Duncombe 2014), due to the barrier to assess the technology, which created what is termed Digital Divide. The increased technology development of computer chips resulted in the invention of mobile technology, which enabled a large number of people, especially in the developing world. The access to technology helped to address the first order Digital Divide (Dewan & Riggins 2005), which access to technology. The second order Digital Divide (Dewan & Riggins 2005), which relates to the effect use of ICT by the developing world for economic development, has still not be addressed (Heeks 2009). The second order Digital Divide is caused by the lack of detailed understanding of the unique local characteristics of each area and the unique requirements of the people in the developing world, in order to develop technologies and applications that will be easily understood by its recipients and also provide the anticipated benefits to them (Heeks 2009). The has been shown by the failure of technology transfer to developing countries (Hilbert 2016), which was based on theories of Modernisation, which presumed that to expedite the progress of developing countries; technological knowledge, tools and techniques developed in the West could be used directly to develop economies that are poor (Qureshi 2015).

### 1.4 Economic priority of AI and ML enabled ICT systems as opposed to development aspect

While the emphasis on ICT usage has been to increase productivity of the firm following the mechanisation of Industrial Revolution where information technology became critical to make production efficient and effective (Acs 2006), the advent of personal computers (PC) was aimed at augmenting the capabilities of the user (Engelbart 1962), which notion was soon forgotten when it was realised that PCs could be networked together to derived the same benefits as the large computers but at a fraction of the costs, and therefore the economic consideration took precedence to the initial aim of the PC. The focus on high productivity using AI and ML systems results in the undermining of development aspects of these new technology resulting in massive job losses (Autor 2015).

## 2 The relationship between ability, capability and experience

## 2.1 Enhancement of abilities and capabilities through experience

The post Modernisation approach tried to put the human beings back into the equation for the sustained economic development, especially of the developing world, by emphasising on using the technology to enhance the capability of a human which will result in the sustained usage thus affect the economy positively (Sen 1999). Capability is based on experience which is the accumulation of specific knowledge to perform certain tasks. The commonly mentioned source of experience is the accumulation of the " … heterogeneous experiences, repeated exposures, stimuli, sense perceptions, and observable environmental contingencies…" (Felin & Foss 2010). But the question that needs to be answer is the original of experience which is the very initial experience that forms the basis of the repeated exposure. Also literature on absorptive capabilities place emphasise on the function of prior related knowledge as to confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends (Cohen & Levinthal 1990). This knowledge can then translated into routines of the company, which are defined as pattern of behaviour that is followed repeatedly, what (Eisenhardt & Martin 2000) calls substantive capabilities, that can be subjected to changes if conditions change, referred to as dynamic capabilities as defined in (Eisenhardt & Martin 2000), which are capabilities to alter substantive capabilities. Many of these routines form the bases and the background of ICT systems, programs, databases, and application, as well as alleviating information overload by converting tacit knowledge into Knowledge Base and Knowledge Management systems (Snowden 2002). Prior knowledge has also been identified as the source of opportunity discovery. The idiosyncratic information a person possesses allows him/her to find particular opportunities that others cannot see (Shane 2002) and the difference between performance of two people in the opportunity discovery is caused by information asymmetry (Kirzner 1997).

## 2.2 Exogenous and post factum approach to experience development

The most espoused view of experience accumulation is the repeated performance of the required action until certain level of efficiency and effectiveness is achieved (Chomsky 1975; Popper 1972). For learning and development theoretical consideration it is was noted by (Felin & Foss 2010) that the important factor, in the experience debates, is the source of the ability and the capability to repeat the required actions

that forms the basis of the experience before we investigate the extent and for how long there are repeated to acquire a certain level of experience. Also the selection of the type of experience required is based on some decision (Popper 1972), therefore a person does not start with a blank state of conception, but do have some preliminary knowledge of some sort which affects the rate of absorption capability and the amount of repetition in order to accumulate the required level of experience.

### 2.3 Endogenous and ex ante approach to experience development

The question is how this initial and preliminary knowledge or experience acquired. (Felin & Foss 2010) points to *ex ante* ability to manage the experience and the capability to even discern and recognise the experience as priori factors. In other words, for all learning there must logically be an ex ante ability to 'handle' the experience and furthermore the capability to discern and recognize stimuli, which has less to do with the characteristics of the stimulus itself and more to do with the underlying characteristics, capabilities, and choices of the organism. This a priori factors have been identified by (Chomsky 1975) as a theory when he describe the way a child develop the ability to recognise and the capability to use a language from restricted, sparse and highly degenerate data sample by constructing a theory of language which he/she then generalises to many sentence beyond the sample. This theory has a predictive scope that is far more than the sample data. Also (Popper 1972) has observed that any observation are based on hypothesis. (Chomsky 1975; Popper 1972) included imagination, together with hypothesis and theory, as the basis for initial experience. This process creates a code with predictive scope which (Tenenbaum et al. 2011) define as a probabilistic generative mental model that describes the causal processes which give rise to observation of objects as well as to sense latent objects that support prediction, judgement and action. There is a normative aspect of this code which is established by cultural practises; but for tasks that require explicit conscious manipulation, which must be learned through training or experience in order to become fluent with those tasks, the individual can begin to deviate from the initial theory or hypothesis by developing new hypothesis and theories that are required by these more cognitive tasks (Tversky & Kahneman 1974; Tenenbaum et al. 2011). Also it has been discovered that the effect of ethnic products and service based online business, in particular, and

any computer social network communication, in general, enables the ethnic entrepreneurs to break away from the initial theoretical or hypothesis code that has been derived from the socio-economic institutional settings (Anwar & Daniel 2017). Nevertheless the initial starting point for this deviation from the theoretical hypothetical code is the endogenous knowledge and abilities of the entrepreneurs. These two researches, and many other similar researches, give us clues on how to move away from the deterministic notion of exogenous factors - like repeated experience, social, economic and institutional settings - as the only cause factor to influence the adoption of new technology and the view that the normative factors are the main barriers to adoption of ICT technology by developing countries. They, therefore, introduce the element of agency in the adoption of technology (Anwar & Daniel 2017).

## 3 Disproportionate possession of ICT technologies between developed and developing world

The question of endogenous knowledge and experience is also relevant within the 4$^{th}$ Industrial Revolution era which has artificial intelligence, machine learning and Big Data analytic as its big components. This is due to the fact that these technologies are predictive in nature and are not theory driven, but rely on existence of vast amount of data relevant to the phenomena under investigation (Hilbert 2016). The main point of departure is *ex factum* knowledge which is used for predictive purposes. Currently there is a still digital divide in the Big Data analytic due to the fact that high possession of ICT infrastructure, internet transaction, Data Analytic skills and education, still reside with the developed world (Hilbert 2016) and as a result, there is a disproportion supply of data and therefore representation of data and information in the Big Data between the developed and developing world.. Since these technologies rely on *ex facto* data that exist in the Big Data, the third world cannot benefit to the same extent as the developed world from the use of Big Data. To overcome this, *ex ante* methods are required to provide information relevant to the developing world in order to benefit from these technologies (Hilbert 2016). The appropriate theories have to be

developed that will represent the endogenic aspect of Big Data to compensate for the missing information.

## 4 Local and relevant theory and hypothesis development

One method that can be used to determine the ways ethnic population in the developing world build their endogenous knowledge is through their use of metaphors to form imaginary scenarios, and therefore imaginary experiments (Weick 1989), in order to develop hypotheses and eventual ground them in empirical experience, resulting in local theories. Imaginary experiment can be analysed by simulation using social-scientific models (Godfrey-Smith 2009). These models are built from memory to make sense of a phenomenon to be investigate in order to develop an appropriate theory to explain and predict the phenomenon (Gregor 2012). They can simulate the endogenous ways ethnic people from the developing countries develop and construct the basic structure that form the basis for absorption and assimilation of new knowledge, and thus to turn them into experience (Cohen & Levinthal 1990). This understanding is critical in the development of appropriate computer application that will try to address the appropriate requirements of the people from the developing world, as well as improve the probability for their adoption.

## 5 Artificial Intelligence and Machine Learning Technologies

Artificial Intelligence and Machine Learning technologies have started to revolutionalise technology that is used to solve complex and difficult problems, which was not possible before. In the wake of this revolution some of the tasks that were traditional reserved for human, because of the high cognitive content required, have are become candidates for replacement by these technologies (Autor 2015). This is not only affecting the developed world but also have a drastic impact on the developing world, given the number of technology divides that they are subjected as a result and also have negative social and economy impact. The shining light through all this is the possibility of complementing some of the functions of these new technologies by

identifying specific tasks that can still be done by humans (Autor 2015). Also a number of research are being undertaking on how these new technologies can also interact with humans in order to assist them with their tasks (Livinus et al. 2016; Amershi et al. 2014; Kulesza et al. 2015).

Other research are focused on developing artificial intelligence and machine learning based systems that will have cognitive capabilities that are similar to those of human being. For instance (Tenenbaum et al. 2011) is developing a machine learning Bayesian based system that tries to account for endogenous knowledge that enable human to generalise from sparse data and beyond the sample data, to complete understanding without been exposed to complete data sets (Tenenbaum et al. 2011). The key questions these algorithm are trying to address are how to represent the prior knowledge, since this is essential to the predictive capacity of the algorithms and the Big Data analytics (Hilbert 2016; Tenenbaum et al. 2011).

In their research (Tenenbaum et al. 2011) are trying to ascertain three basic questions which are:-

1) How does abstract knowledge guide learning and inference from sparse data?
2) What forms does abstract knowledge take, across different domains and tasks?
3) How is abstract knowledge itself acquired?

They found that Bayesian models can provide answers to these questions through their ability to structure and represent expressive knowledge (question 2), and have a powerful statistical inference engines (question 1 and 3), and they then argue that this type of sophisticated synthesis approaches to both knowledge and representation and inductive inference can account for human intelligence (Tenenbaum et al. 2011).

# 6 Simulation model for investigation and theory development

## 6.1 Scientific simulation model to perform imaginary experiments

Despite the findings discussed above, there are still a number of issues on how the initial prior knowledge is acquired on which the Bayesian models and Big Data analytics depend. The combined use of scientific-model simulation (Godfrey-Smith 2009), experiment of the mind with metaphor (Weick 1989) and the various Artificial Intelligence and Machine Learning techniques could be the answer on how resolve the issue with the prior knowledge.

(Godfrey-Smith 2009) investigate how scientists investigate things that are known not to be parts of that world, e.g. ideal gases, frictionless planes, etc. These are imaginary objects which have become common properties for the community of scientists. These imaginary objects can be investigated using what he calls "model-based science". He then postulated that other fictional objects can also be investigated through simulation. Some of these objects fall under the banner of metaphysics. These can then also include spiritual phenomenon, Eastern philosophy, biblical parables, and African ancestry accounts. The metaphysical object can be used to investigate and explain some aspects of objective world that are related to these metaphysical objects (Godfrey-Smith 2009).

## 6.2 Using simulation and imagination to develop endogenous theory

The philosophy of sense making described by (Weick 1989) places imaginary experimentation as a mode for theory development. These imaginary objects are fictions which can be investigated scientifically (Godfrey-Smith 2009). Simulation models are used, especially where there is not *ex-facto* data available. They can therefore be used to account for endogenous information to explanation the occurrence of some phenomenon as well as to explicate the causal nature of related objects (Felin & Foss 2010). They also used for complex interactive actions of multi-agents to simulate

emergent properties from the interactions (Hédoin 2013; Enrique et al. 2014). These explanations are the basis of middle-range theory, which is local in nature as opposed to the covering law (Hedström & Swedberg 1998; Avgerou 2013).

## 7 Conclusion

In trying to develop local theories in order to solve the problem with the adoption of technology by developing world deeper understanding of the endogeneity of the knowledge of the population of the development countries is important in order to develop appropriate complementary ICT technology that will accommodate this kind of prior knowledge and help integrate it with globally recognisable knowledge. This is a necessary step in the process of enabling them to use their abilities and capabilities to participate in the global economy for the benefit of their countries.

With the knowledge it will be possible to determine how to use Artificial Intelligence, Machine Learning and Big Data analytics for the benefit of the developing countries and, at the same time, discover opportunities to complement the 4$^{th}$ generation industrial revolution and use it to leverage their development

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