

# MACHINE INVENTION SYSTEMS: A NEW APPROACH TO INNOVATION

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## INTRODUCTION

The momentum gained by recent developments in the field of digital transformation and machine learning show an increasing potential not only to replace dull, dirty or dangerous jobs <sup>[1]</sup>, but also in service and management areas, jobs with self-actualization potential <sup>[2]</sup>. One area in particular in which new systems are emerging is the generation of new or previously unexplored knowledge and models – i.e. invention. These new types of systems, coined Machine Invention Systems, will be explained in more detail, at first through examples and then through brief theoretical considerations in the following sections.

## CURRENT APPLICATIONS

In order to create a better understanding on the nature of these systems and to exemplify their abilities, a cross-industry list of current applications has been compiled (Table 1). Due to the novelty of the field and the lack of a clear denomination for such systems until now, the following examples represent only the few applications that have been validated to contain – partially or totally – machine invention systems.

In the field of Robotics, in order to achieve physical locomotion without any indication on how to achieve it, Darwin <sup>[3]</sup> uses simulated neuronal networks to ‘imagine’ how movements should be done and then with the use of a secondary neuronal network perform the movement. In the field of virtual locomotion, DeepMind presented a system<sup>[4]</sup> that can achieve locomotion under a series of constraints and exhibited an ability to optimize and adapt its movement given no set of rules on how to do so.

Category	Field	Application
Robotics	Physical Locomotion	Darwin
	Virtual Locomotion	DeepMind Locomotion
Defence and Security	Aircraft manoeuvres	LCS Fighter
	Cybersecurity	LCS Cybersecurity
Fine Arts	Musical Composition	Kulitta
	Image Creation	CNN Imaging
Cognitive Science	Quantum Physics	Melvin

**Table 1:** Overview of the current applications of Machine Invention

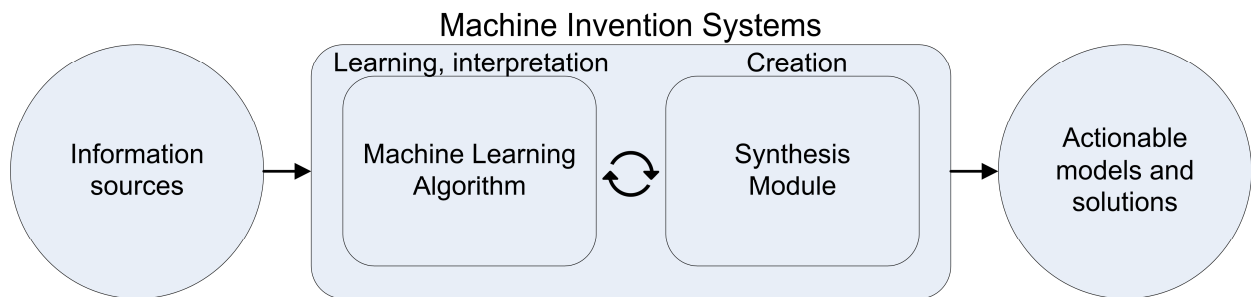
In the Defence and Security category, a Learning Classifier System based on a genetics-based machine learning algorithm<sup>[5]</sup> is used to find best-expected-result manoeuvres to counteract enemy fighters. Also in this category, Learning Classifier Systems can be used to search continuous streams of data for potential threats<sup>[6]</sup>, learn and improve their detection models in order to allow for a fast and steadily evolving detection mechanism.

In Fine Arts, there are musical composition programs like Kulitta<sup>[7]</sup> that can develop new and unique music scores based on a multi-stage approach machine learning algorithm. On the visual side, Convolutional Neural Networks have demonstrated an ability to interpret images and create new and unique renderings of existing objects and features<sup>[8]</sup>.

Finally, in the field of quantum physics, a topic that resists human logic often, an algorithm called Melvin<sup>[9]</sup> can devise new viable experiments based on its own generated models that further our understanding of the field.

## THE CONCEPT OF MACHINE INVENTION SYSTEMS

Although these applications stem from a large variety of fields, their commonalities allow for the development of a concept. One important observation is that all the above applications exhibit some form of machine learning. However, what differentiates these systems from common machine learning systems is their output. Rather than limiting themselves in finding hidden linkages between factors, or creating statistical analyses on the available data, they use these solutions to generate higher-level models and solutions and test them accordingly. Figure 1 presents the current model of the machine invention systems, together with its most important attributes.



**Figure 1:** Block diagram of the Machine Invention Systems

Based on the available data and the current development of the model, we can propose that machine invention systems are cyberphysical or virtual systems that can create actionable models and innovative solutions by processing and deriving higher level concepts and models from unorganized information sources.

## OUTLOOK

Current efforts focus on understanding what the different categories of machine innovation systems are and what opportunities and challenges are faced by these systems. Furthermore, investigations on the optimal conditions for integrating these systems into the production environments are planned, as well as ethical and societal implications of the knowledge wealth generated by them.

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