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Scope and potential applications of artificial intelligence in tropical tasar silkworm *Antheraea mylitta* D. seed production

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Abstract
In the current era, artificial intelligence is used for man-made things which have the ability to think, understand and learn, *i.e.* machines which can not only think and understand like humans but also take decisions on its own based on the situation. The human teaches the machine that for this particular activity you should do this with specific output and leaves the machine on its own where the machine learn automatically by its past examples. After the digitalization, the importance of artificial intelligence has increased greatly. If suitably developed and implemented, it has the potential to revolutionize many sectors. Although many fields are being utilised for the implementation of artificial intelligence to bring comfort to the human beings, the tasar silkworm seed production also offers this technology various scopes to expand its application in tasar sericulture. Further, based on the Generative Adversarial Networks (GANs) technologies of machine learning ,the potential applications of artificial intelligence in tropical tasar silkworm seed production are also discussed. However, systematised research, planning and execution are essential to witness the full benefits of artificial intelligence in tropical tasar silkworm seed production.

Keywords: AI, machine, intelligence, sericulture, tasar, *Antheraea mylitta* D

Introduction
Earlier machines resembling humans and thinking like humans and taking decisions like humans were part of fantasy, literature, pictures and films. After that, slowly these machines started entering our lives and now they have become the truth of our lives. Imagination of life without it will become more difficult in the coming days. That is, those who are not used to them should learn to live with them. In view of this, many countries in the world are trying to create a machine learning ecosystem. In the current era, machine learning ecosystem, artificial intelligence is used for man-made things which have the ability to think, understand and learn, *i.e.* machines which can not only think and understand like humans but also take decisions on its own based on the situation. For example driverless/autonomous vehicles where computer is the driver, this computer collect data from laser, proximity sensor and GPS technology and thus prevents accidents and reaches the destination (Khayyam *et al*., 2020) [4].
Like our five senses give us information which goes to our mind and based on this, our brain determines an action, the artificial intelligence will also take data from different sensor networks and then determine what decision should be taken for a particular area. Some people understand that the technology of making robots as artificial intelligence but it is not completely correct. Artificial Intelligence is the most advanced form of computer science in which a brain like thing is created, rather than a robot, through which computers can think and act, *i.e.* computer brain that can work like humans brain. Robots are no longer machines; they have started thinking and realizing things and act like humans. For example humanoid robots: cook, electrician, mechanics, officer, plumber, teacher, waiter and welder robots (Popovici 2018) [9]. Now there are machines which learn new things daily, understand the act, argues and giving feedback on the idea.

Artificial intelligence
Artificial Intelligence defined by Grewal 2014 as "the mechanical simulation system of collecting knowledge and information and processing intelligence of universe:

(collating and interpreting) and disseminating it to the eligible in the form of actionable intelligence". Artificial intelligence simply means developing the ability to think and understand in a machine. Currently, this ability is in humans and other living organisms. These abilities include seeing *i.e.* visual perception, hearing *i.e.* speech recognition and decision making. Through artificial intelligence, computer can listen to our commands, recognize our voice or may understand the difference between a lepidopteran and a hymenopteran insect.

Machine learning

Just as a kid, is taught to walk, speak, run, read and write, similarly the computer is taught everything through machine learning, language and commands to make it artificially intelligent. Machine learning uses various programs such as image processing, symbolic learning, computer vision and robotics. Through machine learning, the program automatically studies thousands of examples and builds an algorithm and after getting the required result, it gets smarter and fine-tuned. Human inputs are required to teach the machine. The human teaches the machine that for this particular activity you should do this and its output should be what we desire and leaves the machine on its own where the machine learn automatically by its past examples. Hence, the basic information bases (database) and the cycles or process utilized to populate these information bases into the machines should be trustworthy, secure and regularly updated.

The traits of artificial/machine intelligence includes capability of motion, perception, prediction and adaptation, making decisions on its own, continuous learning and forward looking (Mohammed, 2019) [6].

Potential applications of artificial intelligence

After the digitalization, the importance of artificial intelligence has increased greatly; the work that takes a human to complete in months can be done in a very short time through artificially intelligent machines and this is the reason why the demand for artificial intelligence is increasing in every field. Its advantages over the natural intelligence includes being more lasting, consistent, less expensive, ease of duplication, dissemination and documentation besides performing certain tasks much faster and better than the human (Pannu 2015).

If suitably developed and implemented, it has the potential to revolutionize the way surgery is taught and practiced (Hashimoto *et al*., 2016) where tiny robots with nanotechnological needles would perform surgeries thereby minimising the interventions of humans. Further, this technology could be seen potentially in the diagnosis of disease and performing X-rays. Similarly, it could be utilised in different fields like agriculture, sports, space, cyber security, business intelligence, manufacture, education *etc*.

The applications of artificial intelligence in agriculture includes drones for precision irrigation, detecting diseases in plants, insect pests and poor nutrition on farms, counting/tracing animals, flood management, drought intensity tracking, pest forecasting, smart digital scouting and reporting, monitoring crop and soil health, weed control *etc*. Thus it helps in increasing productivity. Further, it is reported that Japanese farmers using artificial intelligence in sorting the harvested cucumbers of different size and shape (Taysom 2020) [11].

Scope of artificial intelligence in tropical tasar silkworm seed production

The silk is produced commercially through the cultivation of different varieties of silkworm *viz.*, mulberry, tropical tasar, temperate tasar, muga and eri silkworms. The tropical tasar silk is produced by silkworm, *Antheraea mylitta* D. and it is preferably used for commercial exploitation in the tropical zone of India where it is source of livelihood for poor and tribal farmers of different states (Nadaf *et al*., 2019) [7]. During the grainage operation/activities of this insect to produce seeds (eggs), which are to be supplied to the farmers for their rearing on host plants in the larval stage to harvest cocoons, which in turn adds to the raw silk production, many challenges are being faced. Hence, the technological interventions through artificial intelligence in the following aspects of tropical tasar silkworm seed production are required to be addressed.

1. Tasar cocoon harvester: Presently the branches with cocoons are being cut with secature and later on the cocoons are being removed from these cut branches where it is requiring more time and human resources. Hence, a machine which could harvest the cocoons with no or less branches being affected is required.

2. Tasar cocoon sorter: The practice of selecting seed cocoons involves the parameters like live pupa, heavy weight cocoons, shell weight, non-filmsy/non-dead/non-infested cocoons. An auto sorting machine based on these parameters to select quality seed cocoons avoids the present manual selection of seed cocoons and also the inferior quality cocoons *i.e.* uzi fly and yellow fly infested, flimsy, low shell weight, dead etc shall be eliminated.

3. Tasar Seed Cocoon Garlander: The quality seed cocoons are being garlanded at the rate of hundred cocoons per garland for the preservation of these cocoons till adult emergence from them to proceed with seed production activities and upon the emergence of adults, these cocoons are to be degarlanded as they become pierced cocoons. This whole process of garlanding and degarlanding demands human resources. Hence, an instrument which could auto garland these cocoons as well as degarland them would enhance the ease in these activities thereby helps in reducing manpower.

4. Tasar cocoons preservation: At present the required abiotic factors in the grainages where cocoons are preserved are being maintained manually based on the daily and timely readings of temperature and humidity in the room/ grainage house. Such an facility which could auto sense the changes in abiotic factors and accordingly take steps to increase/decrease temperature and/or humidity will definitely prevent the erratic and unseasonal emergence, thus will reduce preservation loss.

5. Moth collector and handler: Upon the emergence of adults from cocoons especially in the early morning when it is usually difficult to notice by humans, they fall down sometimes on the floor of the grainage and thus may not be in a position to mate. Further, after moths completes the mating they are to be placed in the oviposition cups where it becomes necessary for human intervention with hands. Therefore devicing such a mechanical device where it prevents falling

and collects moth and also such a handler to transfer the coupled moths to oviposition device helps in getting more DFLs from less number of cocoons.

6. Tasar silkworm artificial insemination machine: During the grainage, some of the moths remains unmated because of unavailability of opposite sex to mate as generally it is difficult to expect synchronized emergence of both sexes in proper proportions in the tasar seed production. As a result the unmated moths are to be subjected for net based or artificial coupling techniques. However, the technological interventions in the form of artificial insemination machine enhance the seed production.

7. Grainage house disinfection: On daily basis during the seed production, the waste generated on the floor of grainage is to be disposed of to maintain hygiene condition. Hence, a kind of wiper which collects all the generated waste in one direction and subsequently dispose of in an appropriate scientific manner and also a device which can sanitize entire grainage house after grainage helps in keeping the sanitation.

8. Egg scrapper: Upon the completion of egg laying by moths in the cups, the laid eggs are being scrapped as of now to collect them for further processing. However, during the scrapping, some of the eggs may get damaged and some may remain without dislodging from the cups thus which may not add to the DFL production. Keeping this in view a tool to scrape and completely collect the laid eggs and which can also accomplish surface sterilization too is necessary.

9. Pebrine detector and sorter: An instrument in the form of scanner which upon placing on the eggs, larvae, pupae, cocoons or adult moths could provide us the details of presence or absence of pebrine spores. Such an instrument is definitely going to prevent the pebrine in the seed production chain and helps the present manual screening/microscopic examination for the spores and it shall revolutionize silk production. Similar device can also be utilised to do moth examination by examination of smear and sorting/discarding the infected lot.

10. Tasar DFL Transport bag: Since the DFLs are to be supplied to many places where the transportation is required and during the transportation, it is necessary to maintain the optimum temperature and humidity along with prevention of mechanical injury to the seeds. It reminds us to think of such a bag/intelligence system for seed transport, which automatically maintains ambient environment.

11. Pierced tasar cocoon grader: The seed cocoons after their utilization in seed production results into a pierced cocoons. At present their disposal is based on different grades, which accordingly attracts different prices for them. The grading of such pierced cocoons which are being generated in many lakh every year in the seed production system requires artificially intelligent technique.

Tasar Cocoon harvesting

Tasar moth ovipositing in earthen cup

Tasar Seed cocoon garland & preservation

Tasar cocoon sorting

Potential applications of artificial intelligence in tropical tasar silkworm seed production

Based on the Generative Adversarial Networks (GANs) technologies of machine learning (Goodfellow *et al*., 2014 and Richard 2020) [1, 10] where it is able to generate new content through implementation of generator and discriminator by neural networks (LeCun *et al*., 2015) [5], the potential applications of artificial intelligence in tropical tasar silkworm seed production are expected to be as follows.

1. Interactive generating adversarial networks (I-GAN): When two host plants of different visible characters are grafted together, this technology through interactive generating adversarial networks helps in generating the images of such resultant host plant before actually performing the grafting.

2. Conditional generating adversarial networks (C-GAN): This technology through conditional generating adversarial networks could help in generating the expected results based on image input and storage condition. For example if it is provided the machine with inputs of tasar seed cocoon images and specify the conditions like what happens to these seed cocoons if stored at particular temperature or relative humidity or for days (conditioning), then this technology would probably provide us the expected images of these seed cocoons after storing under those conditions before actually storing them.

3. Generating adversarial networks-negative samples (GAN-Negative): The artificial intelligence through its generating adversarial networks-negative samples would also probably use images of yellow fly or uzi fly infested cocoons or pebrinised tasar silkworm or flossy or dead cocoons for what we don't like to generate or produce and thus could help in making generations more controllable.

4. Sequence generating adversarial networks (S-GAN): Through sequence generating adversarial networks, this technology probably helps in taking up natural sequence farming where it might generate guidance on reserving farms to recover fertility. Thus its intelligence would be added advantage in planning tasar silkworm rearing crop wise on different patches of plantation in a field.

Further, this technology probably be employed in generating product description like host plant leaves, cocoon, seeds-their color, shape *etc* based on their images as inputs and also in predictions where based on the news reports on imports and exports of silk, using such summarised reports, artificial intelligence predicts demand and supply of silk in the ensuing years.

Negative impacts of artificial intelligence

Though artificial intelligence may have many benefits for modern world, however, alongside the good, there will predictably be cons too. The sooner we start to consider what those may be, the better prepared we will be to alleviate and deal with the risks. Impacts or results of machines shall be biased if artificial intelligence algorithms are built with a bias. The other impacts associated with artificial intelligence are lack of human requirement inturn affecting job avenues to marginal persons, shift in human experience, accelerated hacking *etc*. It is being said that when the machines will do all the work of human beings, then what will humans do?

It is to note that such technology will demand people or generate jobs to create artificial intelligence and when an artificial intelligence system is built; it has to be maintained where skill human intervention is required. Additionally, repairing, manufacturing and selling of these machines also need human intervention. However, over the cons, the pros are more like saving time, better output, more revenue, improved production system etc.

Conclusion

Many countries are already promoting and implementing the artificially intelligent system. These technologies are being employed in some selected fields where these programs are able to crawl collected information quickly and understand patterns which humans simply cannot in order to attain increased productivity by giving industries the upper hand in terms of gaining insights to drive product and marketing decisions (Nawaz 2020) [8]. Similarly the tasar silkworm seed production also offers this technology various scopes to expand its application in tasar sericulture. However, systematised research, planning and execution are essential to witness the full benefits of artificial intelligence in tasar silkworm seed production. For the sericulture industry to be competitive in the world, building relationship with skills and techniques of artificial intelligence is necessary. Failing to change in accordance with advancement in technology may affect the production capabilities in future of the industry.

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