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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(12): 198-202

www.thepharmajournal.com
Received: 26-10-2022
Accepted: 29-11-2022

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Artificial intelligence glimmer of hope for reviving the sericulture industry in Jammu and Kashmir

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Abstract
Sericulture is a cottage business based on agriculture with significant potential to provide jobs in both urban and rural locations. However, in order to make the sericulture sector sustainable, several processes need to be changed through the use of smart technology. Practically speaking, environmental factors that affect silkworm rearing are highly challenging to manage and a danger. The process of manually counting silkworm eggs by individually marking each one with a pen or marker. Poor pen quality can cause silkworm eggs to break, and grainage loss. Along with impairing accuracy, continual reckoning can result in headaches, eye fatigue, vertigo, and other symptoms. Manual procedures produce erroneous results and take a lot of time. The separation of the sexes during breeding programmes also requires a lot of labour and time. It is difficult to thoroughly research diapause, internal egg development, and to count, identify, and categorise healthy and ill silkworms. The safe and assured healthy growth of the silk worms is achieved with the aid of technological intervention, which is computer-based techniques such as Artificial Neural Networks (ANN), Internet of Things (IoT), Artificial Intelligence (AI) approaches, and Image Processing Algorithms, fully equipped disease detecting and protection through automated spaying medicine system. The automated method will eliminate the need for additional labour and eliminate the possibility of human error. As a result, models must be developed to encourage the application of artificial intelligence in the sericulture industry, making it a more appealing and extremely lucrative sector.

Keywords: Sustainable, silkworm, diapause, egg, internet of things and automated

Introduction

Artificial intelligence

Grewal (2014) [20] described artificial intelligence as "the mechanical simulation system of gathering knowledge and information and processing universe's intelligence: (collecting and interpreting) and disseminating it to the eligible in the form of actionable intelligence." Creating a machine with artificial intelligence just involves giving it the capacity to reason and comprehend. Currently, only humans and other living things have this ability. These skills include hearing, or speech recognition, making decisions, and seeing, or visual perception. Through artificial intelligence, a computer may be able to discern the distinction between a lepidopteran and a hymenopteran bug, as well as respond to human requests and recognise our voice.

Computer learning

The computer is taught everything using machine learning, language, and commands to make it artificially intelligent, just as a child is taught to walk, speak, run, read, and write. Robotics, image processing, symbolic learning, computer vision, and other technologies are all used in machine learning. Through machine learning, the computer automatically analyses tens of thousands of samples, creates an algorithm, and then improves itself after obtaining the desired outcome. The machine must be taught using human inputs. The machine is taught by the human that for this specific activity, you should do this and that its output should be what we desire, and then the human leaves the machine to learn automatically from its prior experiences. Therefore, the fundamental data bases (database) and the cycles or processes used to fill these data bases into the machines should be reliable, secure, and up to date. Artificial or machine intelligence is characterised by the ability to move, perceive, predict, adapt, make decisions independently, and learn continuously (Mohammed, 2019) [24].

The artificial intelligence will also use data from various sensor networks to decide what action should be performed for a certain location, just like our five senses provide us with information that travels to our mind and is then based on by our brain. Though it is not entirely accurate, some people think that the technology used to create robots counts as artificial intelligence. The most sophisticated branch of computer science is known as artificial intelligence, which aims to construct something that resembles the human brain so that computers can think and act like humans do. Robots are no longer considered to be machines because they now act and think like humans. Robots that are human-like include those that are a cook, electrician, mechanic, officer, plumber, teacher, waiter, and welder (Popovici 2018) [27]. There are now machines that continually learn new things, comprehend actions, engage in debate, and provide feedback on concepts.

The present silk output in India is expected to reach 35000 MT in the fiscal year 2022, compared to 91765 MT globally in 2020. problems in the sericulture sector, such as maintaining temperature and humidity levels, cutting back on labour for egg counting, and separating men and women, etc. Continuous counting can impair the accuracy of the results and result in eye fatigue, headaches, and vertigo. Computer-based techniques including Artificial Neural Networks (ANN), the Internet of Things (IoT), Artificial Intelligence (AI) methods, and image processing algorithms must be implemented in order to address these issues in the field of sericulture today. Nowadays, computer-based technologies are far more crucial to achieving concrete objectives in the sericulture sector. It's also helpful in the sericulture sector for, among other things, counting, recognising, and categorising silkworm eggs, fruits, flowers, leaves, and illnesses. In the past, researchers have used deep learning (VGG16, ResNet50, and Inception V3), machine learning (ANN, CNN, Fast CNN, Faster CNN, SSD, Yolo V3, KNN, SVM), and image processing (Violo) techniques to efficiently count, detect, and classify silkworm eggs at low cost. This is because early detection of unhealthy and healthy silkworm eggs leads to an estimated profit. Digital tools are being provided by an Agri-tech start-up in Bengaluru to connect the entire supply chain of the silk industry, helping sericulture farmers earn higher pricing for their produce and ensuring the quality of cocoons and yarn for reelers, weavers, and retailers.

Silkworm eggs are counted using a variety of methods, including human methods, artificial neural networks (ANN), internet of things (IOT), artificial intelligence (AI), and image processing algorithms (Ngo *et al*. 2021; Pathan and Harale 2017; Zhang *et al*. 2021; Pathan *et al*. 2019) [8, 9, 10, 11]. Each egg will be individually marked with a pen or marker before being manually counted. Poor pen quality can cause silkworm eggs to break, and grainages cause loss. Along with impairing accuracy, continual reckoning can result in headaches, eye fatigue, vertigo, and other symptoms. The manual method must be replaced by computer vision with hardware installation since the results of manual methods are unreliable, time-consuming, and require more labour (Pathan and Harale 2016) [12].

One potential use might be in multifunctional silk biomaterials and silk optics, which could be used to track the growth of silkworm eggs and the spinning of silk in the cocoon. Recent advances in emerging silk biomaterials can be attributed to their distinctive combination of strength, flexibility, and lightness (Cai *et al*. 2020; Lee *et al*. 2020; Sun *et al*. 2020) [35, 36, 37]. One of these that has been extensively studied and used in practise is silkworm silk (Wang *et al*. 2019b) [38]. Silk is not only used to make clothing, but it is also used as a flexible protein material with multiple uses, such as coatings for "smart windows"-like thermal regulation applications (Wang *et al*. 2019a) [39]. Xiong *et al*. (2021) [14] used a THz QCL video system to record changes in the internal morphology of silkworm eggs and created a dataset for silkworm eggs that corresponds to both optical and THz images. use data fusion and deep learning to detect different phases of silkworm egg development. Rapid recognition of the silkworm egg development phases is effectively demonstrated using a deep learning system in combination with THz silkworm egg photos, with a recognition accuracy of 98.5%. We increase the AI recognition accuracy of silkworm egg development stages to 99.2% by fusing optical imaging with THz imaging. The suggested THz imaging technology offers not only the inherent benefits of THz imaging but also the short time and high identification accuracy benefits of AI, which can be applied to different application scenarios.

Artificial intelligence applications

The demand for artificial intelligence is rising in every industry as a result of the digitalization, which has considerably raised the relevance of this technology. Artificially intelligent computers can already do tasks that would normally take humans months to complete. Its advantages over natural intelligence include being more durable, consistent, affordable, easy to duplicate, disseminate, and document, in addition to executing some tasks far more quickly and proficiently than a human (Pannu 2015) [40]. If properly developed and deployed, it might completely alter how surgery is taught and practised (Hashimoto *et al*., 2018) [21], allowing for the use of tiny robots equipped with nano technological needles to execute procedures while minimising the need for human intervention. Additionally, the use of this technology in performing X-rays and illness diagnosis is possible. Similar applications could be made in a variety of industries, including manufacturing, education, sports, cyber security, and agriculture. The use of drones for precise irrigation, the detection of plant diseases, insect pests, and poor farm nutrition, the management of floods, the tracking of drought intensity, the prediction of pests, smart digital scouting and reporting, crop and soil health monitoring, weed control, etc. are examples of applications of artificial intelligence in agriculture. As a result, it promotes productivity. Additionally, it has been stated that Japanese farmers are sorting the harvested cucumbers using artificial intelligence, depending on their size and shape (Taysom 2020) [29]

Previously conducted research on sericulture

The major difficulties in sericulture, according to Pavitra and Raghavendra (2022) [6], are to count, identify, and categorise hatched (healthy) and unhatched (unhealthy) silkworm eggs. A number of biological methods can be utilised to get around these problems as well, but they are ineffectual. With the help of cutting-edge sericulture techniques, such as digital machine learning, deep learning methodologies, and image processing, those challenges were successfully solved, leading to improved counting, detecting, and classifying on a single DFL sheet.

According to Reddy and Bhaskar (2022) [1], IoT is frequently used to link devices and to collect data. The system is intended to remotely monitor the applied parameters, such as humidity, temperature, and the build-up of dangerous gases. Using the data gathered, the climatic conditions inside the enclosed environment may be automated. The worms are observed using a camera that records information in the form of images at regularly spaced-out intervals. The information gathered here is used to identify the worm's health or sickness. An automated pump will dispense the medication if it is discovered that the worm is ill. As a result, the method will assist the farmers in reducing the amount of physical labour required for the production of silk and in improving both yield and silk quality. This is accomplished with the aid of IoT, which is used to maintain precise parameters like humidity, temperature, and gases, as well as to monitor and classify in the regulated environment.

Yogeshraj (2022) [31] created an accurate, effective, and simple system for classifying healthy and ill silkworms. The suggested approach also includes a classification based on convolution neural networks, which increases accuracy and speeds up processing. The classification outcomes are also indicated as either unhealthy or healthy silkworm. A deep learning method is CNN. Only the final layer gets trained as a result. CNN also derives the depth, width, and height feature values from the raw pixel information. Finally, the Gradient descent-based loss function is employed to attain high accuracy. It computes the validation loss, training accuracy, and validation accuracy.

A method for classifying male and female cocoons using X-ray imaging without destroying the cocoon was proposed by Thomas and Thomas in 2022. Popular single hybrid mulberry silkworm cocoons FC1 and FC2 were used in the investigation. The pupa's shape characteristics, which were gathered without cutting the cocoon, are taken into account throughout the classification process. The width and height of the cocoon are calculated using a new point interpolation method. Various dimensionality reduction techniques are used to improve the model's performance. The strong ensemble learning technique AdaBoost receives the pre-processed features as input, using logistic regression as the base learner. In cross-validation, this model's mean accuracy was 96.3% for FC1 and FC2, while in external validation, it was 95.3% for FC1 and 95.1% for FC2.

Deep convolutional neural networks are built for image classification by Suvarna *et al*. in 2021 [2]. (Silkworm images). Despite only using a portion of the photos, accuracy of 75% was still achieved. The accuracy would have been significantly higher had the entire dataset been utilised. There is currently no technology available that can be utilised to differentiate between silkworms with diseases and those without them. When a disease spreads throughout a batch of silkworms and kills them all, such technology will assist farmers overcome their challenges and maintain the quality and quantity of the silkworm.

The mulberry leaf yield was predicted by Srikantaiah and Deeksha (2021) [3] using the machine learning models Multiple Linear Regression, Ridge Regression, and Random Forest Regression. The three models' accuracy results are contrasted. The Random Forest Regression model has a 94.6% accuracy rate. In the future, a larger dataset and different feature extraction methods can be used to increase the model's accuracy. Future work could also include suggesting various fertilisers depending on the soil parameters.

A prototype sericulture unit was developed by Deepthi and Sastry in 2021 [5] using IoT and image processing methods. The prototype has various advantages in terms of remote monitoring and automated actuation to suitable conditions inside the system. It will function in real time for parameter monitoring and to control the condition inside the deployed environment. Image processing will categorise the worms as healthy and diseased by identifying the disease using colour change and texture analysis, which involves masking the image using a binary mask to obtain the silkworm, applying colour thresholding to the silkworm's histogram, classifying them into three groups as healthy, Flacherie infected, and Pebrine infected, and notifying the sericulturist about the diseased worm detected as well as the disease of the silkworm using senescence. Future Aims: The suggested method can be improved to process actual silkworm photos that are acquired by a digital camera. As soon as a silkworm is discovered, a robotic arm will immediately separate it from other worms. The image processing system will identify the stages of the silkworm's development and send that information to the internet of things (IoT) so that the climate may be maintained appropriately. Making the system more dynamic and effective than the suggested answer.

Terahertz (THz) imaging technology and artificial intelligence (AI) algorithms were combined by Xiong *et al*. (2021) [14] to achieve the dynamic monitoring of silkworm egg development. By combining intelligent THz imaging with optical imaging, they were able to push the accuracy up to 99.2% and demonstrate for the first-time rapid detection of the silkworm egg development stage with a recognition accuracy of 98.5%. Other application scenarios can be covered by such AI-enabled THz technology.

A prototype was created by Udaya *et al*. in 2021 [13] that has metal grids of varying sizes that vibrate when connected to an electric motor. According to their size, the cocoons were sorted. While male cocoons are lean and narrow, females are thicker. The sorting machine's vibrating grids of varied sizes receive the cocoons and use them to separate the cocoons. The gadget is primarily utilised for rating the quality of Tasar variety cocoons, even though the system was able to attain a sorting accuracy of 96%. After being graded, the cocoons are taken to reeling, where raw silk is recovered from them.

Temperature and moisture in the environment are measured using the sensor, according to Jambukar and Dawande (2020) [4]. The Oracle database was used to further process sensor readings using UART and Python. Data on temperature and moisture are trained to ML using the historical record, and forecasting predictions for the following seven days are made public. On Tableau dashboards, the entire historical and forecasting data is visible. Several environmental elements can be tightly controlled with the aid of this monitoring and forecasting. Based on the information collected from the relevant system, the master control facilitates the best course of remedial action and guides the identified choices.

Joseph Raj (2019) [7] created a machine to classify silkworms depending on gender while they are still in their cocoons without harming the shell, doing it without the need for human interaction. The created technology has the potential to increase grainage facilities' productivity since they are now manually classifying genders. The results of the tests indicated that the proposed approach may be suitable for use in industrial applications, with a maximum accuracy of 93.54% and repeatability of 88%.

Financially astute and energy-efficient framework was proposed by Gunasheela *et al*. (2018) [32]. The model's preliminary testing has shown that it may be developed gradually to track the ranch's natural conditions. The sericulturist's extended proximity to the raising unit is reduced. Utilizing the framework is simple. Future work will use internet, Wi-Fi, and the Internet of Things (IOT) to handle correspondence and secure data.

To categorise the cocoons, Mahesh *et al*. (2017) suggested a brand-new non-destructive vision-based approach. In order to create an integrated feature vector for kNN, LDA, NN, and SVM classifier training, the methodology combined the weight, volume, and ZM-based shape aspects of the cocoons. The performance was compared with that obtained from integrating geometric shape features and integrating weight and volume with geometric shape features in order to validate the integration of these features. The experiment was carried out using CSR2 and pure Mysore breed cocoons. The outcomes showed that NN and SVM classifiers performed better. CSR2 cocoon accuracy with NN classifier was 91.3%, and pure Mysore cocoon accuracy with SVM-based classifier was 100%.

By degumming, or soaking the cocoon in hot water and removing the fibres, Xiaohua (2012) [16] created a technique for detecting male silkworm cocoons. The fibres are then put through a chemical process to determine the gender based on the methionine content and aspartic acid value of three amino acids. This is another manual chemical-based method that involves heating the cocoon, which could harm the pupa.

Raste *et al*. (2014) [33] designed a system to optimise silk yield using artificial intelligence (machine learning) techniques. The system is highly suited for installation in sericulture because it is both cost- and power-effective.

Zhang *et al*. (2010) [18] created a device to distinguish between male and female cocoons by shining ultraviolet light on them. Based on gender, the tested cocoon displayed various fluorescence traits. The fluorescence properties of the male and female cocoons were yellow (wavelengths between 577 and 597 nm) and purple (wavelengths between 390 and 455 nm), respectively. The evaluation is dependent on human vision, and the entire procedure must be done in a dark environment. This approach is labour-intensive and additionally expensive, requiring a 200 W power source and a UV light source with a wavelength of 3600 A. Yang Bin *et al*. (2010) [17] made significant advancements to this technique by automating the procedure based on the fluorescence characteristics offered by male cocoons and combining a photosensitive yellow filter with an ultraviolet filter to identify and distinguish male cocoons from female ones.

Outcome

The safe and healthy growth of the silk worms with modulated temperature control, disease detection and protection are guaranteed with the aid of technological intervention, which are computer-based techniques like Artificial Neural Networks, the Internet of Things, Artificial Intelligence approaches, and Image Processing Algorithms. The automated method will eliminate the need for additional labour and eliminate the possibility of human error. As a result, models must be developed to encourage the application of artificial intelligence in the sericulture industry, making it a more appealing and extremely lucrative sector.

Acknowledgments

The author wishes heartfelt thanks to Associate Dean and Major advisor, CoTS, Mirgund, SKUAST-Kashmir for providing financial support.

Conflict of interest

The authors have no conflict of interest and Nothing to disclose.

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