

EFFICIENCY IN AQUACULTURE THROUGH AI APPLICATION: TRANSFORMING LIVE FOOD PRODUCTION, SHRIMP LARVICULTURE, AND FISH EGG COUNTING

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INTRODUCTION:

The true value of Artificial Intelligence use lies in targeted application to aquaculture operational bottlenecks where accuracy, speed and traceability are critical. Live food production, larval shrimp stocking and culture, and fish egg quality assessment remain highly dependent on manual counting and expert judgement.

MATERIALS AND METHODS

To support the development of the **SnappArt 360** system, advanced computer vision modules were implemented to enable automated detection, classification, and analysis of target features in captured images. The YOLOv4 and YOLOv7 object detection frameworks were selected for their strong balance of accuracy, real-time performance, and computational efficiency in processing visual data.

The overall methodology, illustrated in Figure 1, outlines the workflow for training, validating, and deploying the detection model within the SnappArt environment. This includes dataset preparation, model training using transfer learning, and performance evaluation on annotated image data.

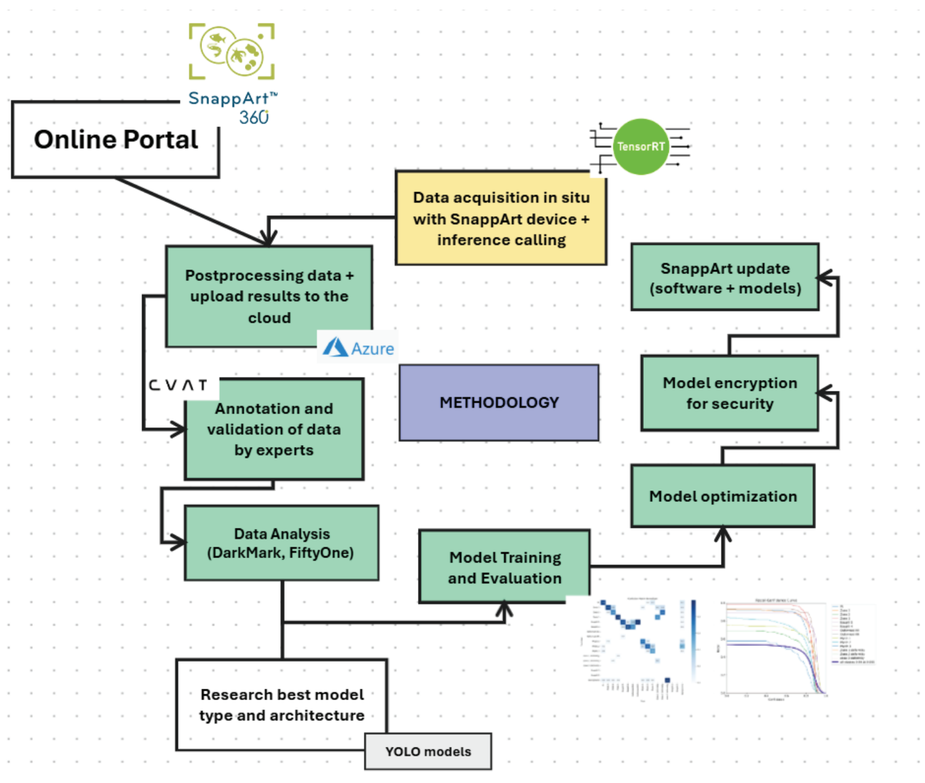


Fig. 1. Integrated methodological framework combining the complex task of preparation of the environment, data acquisition, training of the YOLO model, model evaluation and validation.

RESULTS

The integration of these models into **SnappArt 360** enables rapid, consistent, and user-friendly image analysis across various applications. This approach has resulted in the development of three specialized artificial intelligence models, optimized for both quantitative and qualitative assessment of:

- live feed organisms (Artemia and rotifers),
- larval stages of *Litopenaeus* vannamei, and
- embryonic development stages of different marine fish species.

Together, these models enhance the accuracy, speed, and reproducibility of biological monitoring, providing a robust decision-support tool for both research and operational aquaculture environments.

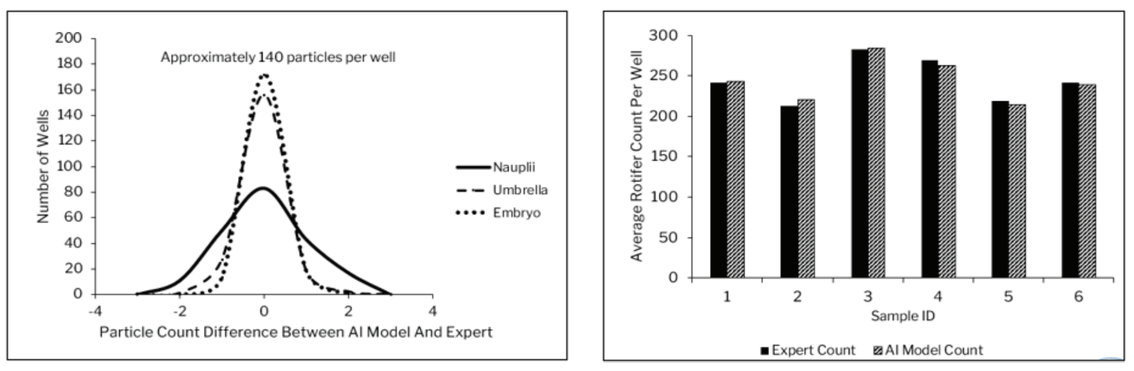


Fig. 2. (Left) Distribution of particle count differences between the Artemia counting model (L-SENSE) and an expert. (Right) Comparison of average particle counts per well across samples, showing Expert Count (dark bars) and rotifer model count (L-Sense, light bars). The results indicate close agreement between methods, with minor variations observed across the six samples.

The **L-SENSE** module provides accurate reporting of number of total Artemia biomass per tank, hatching efficiency, Artemia stage ratios (Instar I–II and umbrella stage), rotifer density, and rotifer fertility (egg-ratio).

The **S-SENSE** module provides precise counting of larval shrimp nauplii of *Litopenaeus vannamei*, larval staging across Zoea I–III and Mysis I–III, and population estimation through a representative sample.

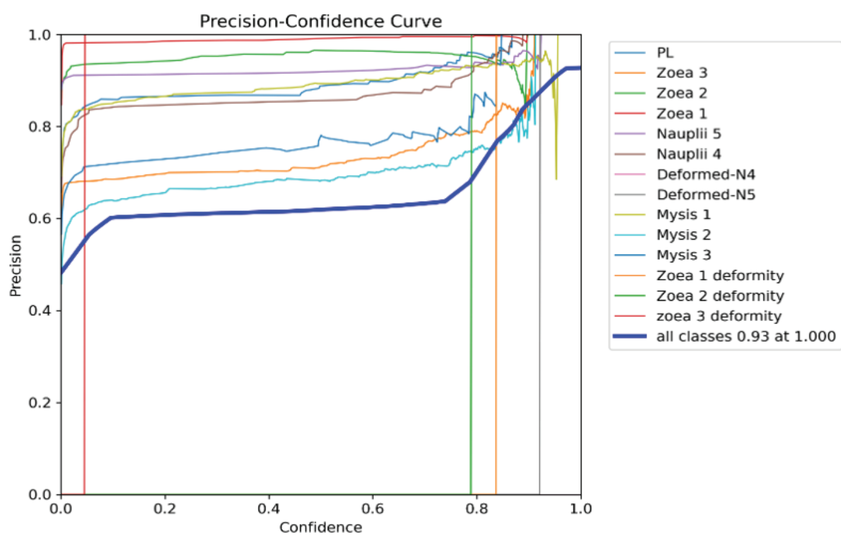


Fig.3. Precision–confidence curve showing model precision (shrimp larvae, S-SENSE) as a function of confidence threshold. The plot illustrates the trade-off between precision and confidence across classes, with class-specific curves and the overall average; vertical lines indicate the selected optimal confidence thresholds.

The **E-SENSE** quantifies and assesses the quality of eggs, the egg developmental stages and evaluates fertilization success with high precision. This module supports multiple species, including *Sparus aurata, Dicentrarchus labrax, Lates calcarifer, Solea senegalensis, Scophthalmus maximus* (syn. *Psetta maxima*), and *Gadus morhua*. All modules report results into dashboard, which simplify the collection and analysis of data and provides a powerful tool for decision-making and traceability of the operations.

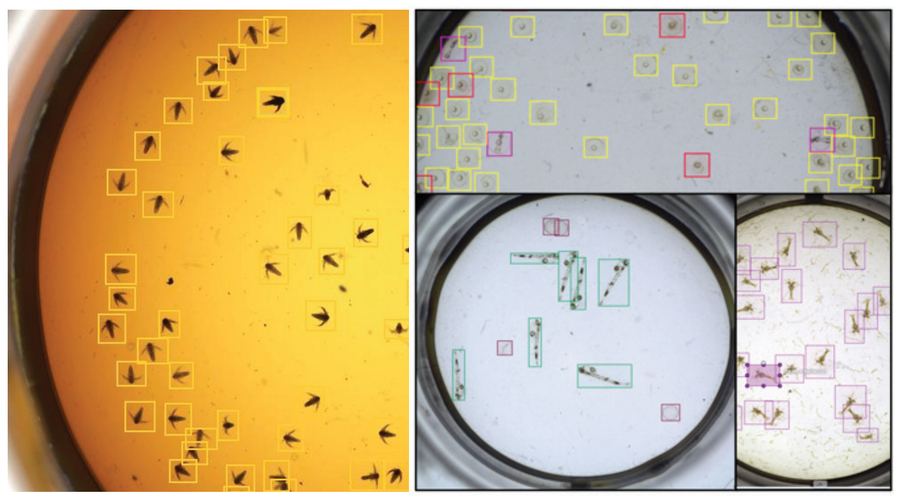


Fig. 4. Representative examples of object detection in well plates. L-Sense (Artemia) on the left, E-SENSE (top and bottom left). S-SENSE (bottom right).

CONCLUSIONS

Across applications, the use of specifically developed AI models delivers standardized and reproducible measurements while reducing labor requirements and operator dependency. It supports data-driven production decisions through cloud-based data storage and dashboards and enables full production traceability.

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