

# Myotube Detection Model using Machine Learning Techniques

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**Abstract.** This study presents a novel machine learning approach for the automated segmentation of myotubes in microscopic images, addressing a crucial step in myogenesis research. We developed and trained YOLO 11obb nano models on a dataset of 400 manually labeled images, achieving an average accuracy of 84 percent. Our method combines outputs from two models trained for 1,000 and 3,000 epochs using Non-Maximum Suppression, significantly improving bounding box precision. This automated approach reduces manual segmentation time (from 2 minutes per image) and minimizes human bias, enhancing the efficiency and reliability of myogenesis studies. Our research supports advancements in understanding muscle development and paves the way for broader applications of machine learning in biological imaging.

## 1 Introduction

### 1.1 Motivation for Work

Understanding the process of myogenesis is critical for advancing muscle development and regeneration research. A key step in this process is the formation of myotubes, which serve as precursors to mature muscle fibers. Dr. K's research focuses on how external factors, particularly alcohol, influence myogenesis, requiring the analysis of large-scale datasets of microscope images to evaluate myotube formation. However, the manual segmentation of myotubes presents a significant bottleneck, demanding extensive time—approximately two minutes per image—and introducing variability due to inherent human bias. These challenges compromise the efficiency and reliability of subsequent analyses, underscoring the need for an automated and consistent solution.

### 1.2 Objectives

This project seeks to address the limitations of manual segmentation by developing a machine learning-based approach for the automated segmentation of myotubes. The primary goals of this study include:

1. Creating a training dataset by manually labeling 400 microscopic images.

2. Training and fine-tuning two YOLO 11obb nano models with 1,000 and 3,000 epochs, respectively.
3. Combining the outputs of both models and applying Non-Maximum Suppression to improve bounding box precision.
4. Evaluating the final model’s performance, particularly its average accuracy and reliability in segmenting myotubes.

Additionally, the study aims to significantly reduce the time required for segmentation and enhance the consistency of analysis, ensuring that research findings are both reproducible and reliable.

### 1.3 Thesis Statement

This study posits that leveraging machine learning, specifically YOLO 11obb nano models, can effectively overcome the challenges of manual segmentation by providing a reliable, automated approach to myotube detection. With an average accuracy of 84%, the resulting model demonstrates the potential to streamline muscle development research by reducing segmentation time and minimizing bias, thus improving the overall quality and efficiency of myogenesis studies.

## 2 Methodology

### 2.1 Dataset

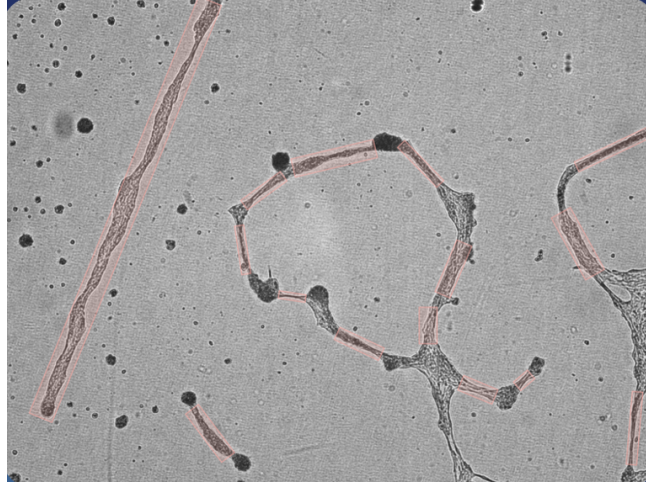
The first step in our methodology was to thoroughly analyze the dataset and understand the objective of the challenge. Our aim was to identify and select images that best aligned with the task of segmenting myotubes during myogenesis, as suggested in Noë et al. [NCW<sup>+</sup>22]. Approximately 400 images were manually labeled to create a robust training dataset. The selected images were chosen to provide diverse representations of myotubes, ensuring that the model could generalize effectively to new data. This manual annotation process served as the foundation for training the machine learning models, offering high-quality ground truth labels.

### 2.2 Experimentation

We approached the solution incrementally, starting with simple preprocessing techniques, such as image filtering, to assess their feasibility for segmentation. However, filtering alone was insufficient for the complexity of the task and was subsequently discarded. Following this, we explored advanced machine learning options, specifically Segment Anything Model (SAM) and YOLO. After evaluating the capabilities of both, we selected YOLO due to its adaptability and strong performance in object detection tasks.

The experimentation phase involved testing various YOLO architectures (YOLO 8 and 11) and model sizes (nano, small, medium) with different training durations (1,000 and 3,000 epochs). As part of the process, we manually labeled

400 images to create a robust training dataset, ensuring accurate representation of the target structures. Additional experiments included incorporating image preprocessing techniques, such as resizing, to accommodate smaller models, though these adjustments were primarily used to optimize computational efficiency rather than improve accuracy. The manual labeling process and resulting dataset are illustrated in Figure 1, which provides a visual overview of the labeled images and highlights the diversity and complexity of the data used for training.



**Fig. 1.** Manual Labelling

### 2.3 Model Development and Fusion

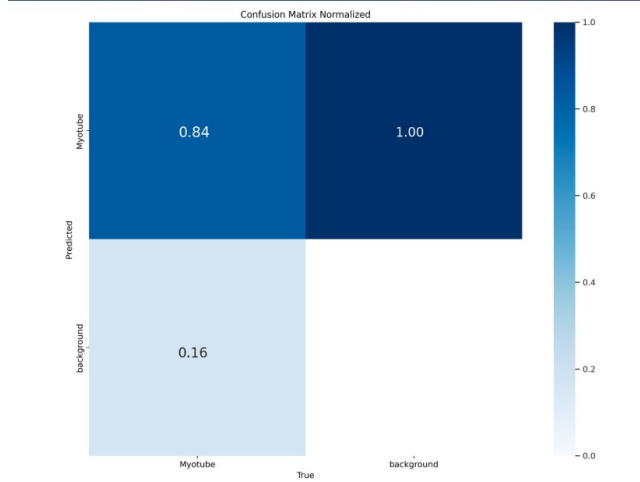
During training, two YOLO 11obb nano models emerged as top-performing candidates: one with 1000 epochs and one with 3000 epochs, each excelling in different metrics. Recognizing the strengths of both models, we sought to create a final model by combining their outputs. Although exploring direct integration through additional training was unfeasible, we applied Nonmaximum Suppression (NMS) to merge the predictions of the two model (as shown in figure 2). NMS reduced redundancy in bounding box outputs, ensuring the final model provided precise and non-overlapping segmentations. This process resulted in a final model with an average accuracy of 84% (as shown in figure 3).

### 2.4 Performance Analysis

To evaluate the model's performance, we employed a normalized confusion matrix, as seen on to assess accuracy and reliability across classes. Additionally,



manual testing was conducted on a separate set of five images to qualitatively verify the segmentation results. The model consistently demonstrated accurate identification and bounding of myotubes, validating its applicability for automating segmentation tasks. The combination of quantitative metrics and manual verification underscored the robustness of the final model in addressing the challenge of myotube segmentation efficiently and reliably.



**Fig. 4.** Confusion Matrix

### 3 Conclusion

This project successfully demonstrates the feasibility and effectiveness of leveraging machine learning to address the challenges of manual segmentation in myogenesis research. By developing and training YOLO 11obb nano models on a dataset of 400 manually labeled images, we achieved a robust automated segmentation model with an average accuracy of 84%. The application of Non-Maximum Suppression further enhanced the precision of bounding box predictions, ensuring reliable and consistent identification of myotubes.

The automation of this segmentation process significantly reduces the time required for analysis, alleviating the inefficiency of manual methods while eliminating the inconsistencies caused by human bias. This advancement not only supports Dr. K's research on the impact of alcohol on muscle development but also establishes a scalable solution that can be adapted to other biological imaging applications.

Future work could focus on expanding the training dataset, exploring alternative deep learning architectures, or integrating complementary preprocessing

techniques to further enhance model performance. Overall, this study underscores the transformative potential of machine learning in accelerating scientific discovery and improving the reproducibility of research findings.

## References

- [NCW<sup>+</sup>22] Simon Noë, Marlies Corvelyn, Sarah Willems, Domiziana Costamagna, Jean-Marie Aerts, Anja Van Campenhout, and Kaat Desloovere. The myotube analyzer: how to assess myogenic features in muscle stem cells. *Skeletal Muscle*, 12(1):12, Jun 2022.