

Machine Learning: Earth

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Computer Vision for White-Tailed Deer Age Estimation: A Dual-Modality Approach Using Trail Camera Images and Jawbone Morphology

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E-mail: aaron.pung@gmail.com**Keywords:** machine learning, computer vision, neural network, deer, age, classification, prediction, dental analysis, tooth wear, wildlife, management, automation, assessment

Abstract

Accurate age estimation of white-tailed deer remains fundamental to wildlife management, yet current methods depend on specialized expertise that severely restricts its widespread application. This study presents two complementary deep learning models that enhance accessibility by automating age classification across different field and laboratory contexts. Our trail camera model analyzes photographs of live bucks, achieving $76.7\% \pm 5.9\%$ cross-validation accuracy, substantially outperforming average human assessment (58.6%) and traditional morphometric approaches (57 – 63%). For post-harvest age prediction, our dental model processes jawbone imagery and achieves 90.7% accuracy while eliminating the need for manual tooth replacement and wear evaluation. Attention map visualization reveals that both models successfully identify the same anatomical features wildlife biologists rely upon: neck, chest, and stomach morphology in trail camera assessments, and dental wear patterns with tooth eruption sequences in jawbone analysis. This biological alignment validates that our models learn genuine age-related characteristics rather than spurious image correlations. The trail camera method enables scalable, non-invasive population monitoring of free-ranging animals, while the dental approach provides rapid, objective verification for harvested specimens.

1 Introduction

Understanding white-tailed deer population demographics remains foundational to ecological management. Amongst other variables, deer age is a primary driver of reproductive capacity, physical development, antler morphology, and offspring characteristics – all biological metrics that define herd health and guide regulatory frameworks for harvest quotas and disease intervention protocols.

However, wildlife professionals face persistent challenges in age determination across two distinct contexts. For living animals, visual assessment techniques rely on morphological cues observable through trail cameras deployed in the deer's environment. "Aging On The Hoof" (AOTH), a non-invasive approach to age prediction, compares relative body proportions and seasonal characteristics of whitetail bucks, yet consistently underperforms relative to management standards. In the case of both trained biologists and recreational observers, AOTH accuracy rates range from 36 – 63%, falling substantially below the 70% threshold agencies require for population modeling and the 80% benchmark researchers demand for demographic studies.

Alternatively, post-mortem analysis offers another prediction method through direct dental examination. When examining whitetail jawbones, practitioners employ two established methodologies: evaluating tooth emergence patterns and enamel degradation (or "tooth wear analysis", TWA), or measuring seasonal growth rings deposited in root cementum ("cementum annuli", or CA). Both approaches exhibit documented limitations. Wear-based assessment proves sensitive to environmental variables including forage composition and soil mineral content, while ring-counting techniques struggle with irregular deposition patterns that compromise interpretation reliability. Investigations comparing the two techniques further reveals inconsistent performance metrics with relative accuracy varying by specimen age class and analyst experience. Laboratory processing capacity further constrains operational utility since specimen backlogs can extend



Figure 1. Text describing the figure and the main conclusions drawn from it. To make your figures accessible to as many readers as possible, try to avoid using colour as the only means of conveying information. For example, in charts and graphs use different line styles and symbols. Further information is available in the online guide: <https://publishingsupport.iopscience.iop.org/publishing-support/authors/authoring-for-journals/writing-journal-article/#figures>

months into the future, creating bottlenecks for agencies processing hundreds of submissions annually.

In an effort to educate hunters and wildlife enthusiasts, outdoor organizations such as the National Deer Association (NDA) create clear instructional videos, pamphlets, posters, and newsletters to teach AOTH and TWA methods. Using photographs, video walkthroughs, and annotated diagrams, viewers are shown numerous examples for different age classes, complete with an age determination and detailed justification. Despite these efforts, though, assessment proficiency remains highly variable and subject to expertise and experience.

As an alternative, automated pattern recognition systems offer a novel solution to these persistent accuracy and scalability challenges. Deep learning and computer vision architectures excel at extracting complex visual features from image data, identifying subtle morphological signatures that correlate with biological age. Such computational approaches operate consistently across specimens, eliminate inter-observer variability, and process submissions at speeds unattainable through manual review.

In this study, we present dual computer vision frameworks addressing both field surveillance and laboratory assessment scenarios. The first model processes trail camera photographs to classify the age of living white-tailed bucks based on somatic characteristics. The second framework analyzes jawbone images to determine age from dental morphology without requiring physical specimen sectioning or microscopic examination. By automating these complementary assessment pathways, we provide wildlife management agencies scalable tools that maintain diagnostic accuracy while dramatically reducing expert workload and analysis turnaround times.

State-of-the-art deer aging practices trail cameras enable hunters and professionals to monitor the movement and health of local deer populations, but estimating the age of white-tailed bucks from camera imagery remains challenging. One technique known as "Aging On The Hoof" (AOTH) attempts to determine age by analyzing the location and date of each image as well as the relative body proportions of the buck in the image [5, 4, 1, 6, 3]. When the buck's body measurements are not known, human AOTH estimate averages just 36% – less than half the accuracy required for management-related selective harvest decisions ($\geq 70\%$) or research purposes ($\geq 80\%$) [2].

1.1 Subsection title

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References

- [1] S. Demarais, D. Stewart, and R. N. Griffin. A hunter's guide to aging and judging live white-tailed deer in the southeast., 1999.

Table 1. Caption text describing the table. Adapt the template table below or replace with a new table. To add more tables, copy and paste the whole `\begin{table}...\end{table}` block.

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Data row 1	1.0	1.5	2.0
Data row 2	2.0	2.5	3.0
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- [2] Kenneth L. Gee, Stephen L. Webb, and John H. Holman. Accuracy and implications of visually estimating age of male white-tailed deer using physical characteristics from photographs. *Wildlife Society Bulletin*, 38(1):96–102, Oct 2014.
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Data availability

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