

Elanco BCS Project Abstract

This team coordinated with Purdue University's Data Mine and Elanco Animal Health in order to solve an issue regarding pet's health centered around an animal's body condition score.

Body condition score, or BCS is defined as a scale usually used by veterinarians to rate the overall condition of a pet (<https://raleighncvet.com>). Not many pet owners are aware of their animal's BCS score and during this past year, it may be difficult or unsafe to travel to a vet's office.

The project's goal is to analyze the different body composition scores of dogs through methods in computer vision.

Currently, the team is developing a calculator to determine the body condition score a veterinarian would use for basic health monitoring, through a simple to use, Android app.

Below is the nine-level Nestle-Purina BCS system. This is the system that the team used for this project.

Nestlé PURINA BODY CONDITION SYSTEM

1 Ribs, lumbar vertebrae, pelvic bones and all bony prominences evident from a distance. No discernible body fat. Obvious loss of muscle mass.

2 Ribs, lumbar vertebrae and pelvic bones easily visible. No palpable fat. Some evidence of other bony prominence. Minimal loss of muscle mass.

3 Ribs easily palpated and may be visible with no palpable fat. Tops of lumbar vertebrae visible. Pelvic bones becoming prominent. Obvious waist and abdominal tuck.

4 Ribs easily palpable, with minimal fat covering. Waist easily noted, viewed from above. Abdominal tuck evident.

5 Ribs palpable without excess fat covering. Waist observed behind ribs when viewed from above. Abdomen tucked up when viewed from side.

6 Ribs palpable with slight excess fat covering. Waist is discernible viewed from above but is not prominent. Abdominal tuck apparent.

7 Ribs palpable with difficulty; heavy fat cover. Noticeable fat deposits over lumbar area and base of tail. Waist absent or barely visible. Abdominal tuck may be present.

8 Ribs not palpable under very heavy fat cover, or palpable only with significant pressure. Heavy fat deposits over lumbar area and base of tail. Waist absent. No abdominal tuck. Obvious abdominal distention may be present.

9 Massive fat deposits over thorax, spine and base of tail. Waist and abdominal tuck absent. Fat deposits on neck and limbs. Obvious abdominal distention.

The BODY CONDITION SYSTEM was developed at the Nestlé Purina Pet Care Center and has been validated as documented in the following publications:
 Manby D, Bortjes JW, Meyers T, et al. Comparison of body fat estimates by dual-energy x-ray absorptiometry and deuterium oxide dilution in client owned dogs. Compendium 2001; 23 (9A): 70
 Luffmann DP. Development and Validation of a Body Condition Score System for Dogs. Canine Practice July/August 1997; 22:10-15
 Kooby, et al. Effects of Diet Restriction on Life Span and Age-Related Changes in Dogs. JAVMA 2002; 220:1315-1320
 Call 1-800-222-VETS (8387), weekdays, 8:00 a.m. to 4:30 p.m. CT

Data: Storage and Use

Use:

- A:T Ratio:** The abdominal to thoracic ratio, taken by dividing the abdominal region by the thoracic region.
- Abdominal & thoracic regions marked up using vertical lines across a silhouette image.
- Lines created through Sobel Operator, Statistical, and DeepLabCut methods.

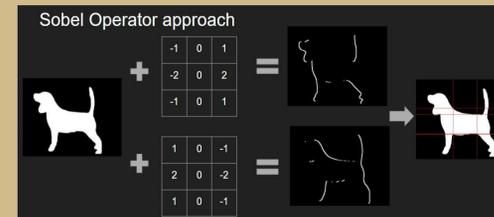


Dog image with a labelled A:T ratio

Storage:

- At first, we marked up images on the slack channel.
- We are now using a student's laptop to store images from the app.
- We plan to eventually store all data on scholar.

Sobel Operator Method



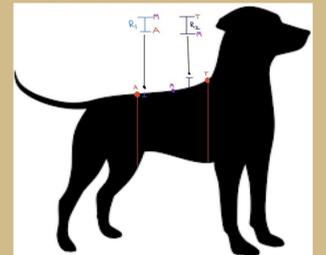
Sobel Operator demonstration diagram

- The team used Sobel-Feldman Operator to draw the horizontal and vertical lines that defines the estimated AT score of the dog within the picture.
- The Sobel Operator was implemented by using a 3 by 3 kernel that extracts "edge" features.
- By applying the kernel twice on the image with opposite directions, the team managed to get the intersection of the body with front leg and hind leg, respectively.

Statistical Method

- Calculate the top middle of the dog (label M).
- Calculate the standard deviation (σ) of black pixel column sums for each black pixel column left and right from M.
- If the σ exceeds some range R1 (left) or R2 (right) draw a red line downwards until we encounter a white pixel. The ratio of the red lines will be our AT ratio

Labeled diagram with points of interest, using the stats-based approach.

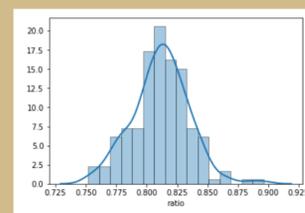


DeepLabCut Method

- DeepLabCut** is a neural network-based software package for animal pose estimation.
- Methods behind the toolbox: transfer learning with deep convolutional neural networks.



Screenshot from labelled video



Distribution of calculated A:T ratio from each frame

- Label the top and bottom side of a dog's chest and waist in frames extracted as training data.
- After the neural network is trained, a new video can be analyzed and the output (x, y) coordinates of labelled body parts can be used to calculate the chest length, waist length and then the A:T ratio.
- By calculating the A:T ratio of each frame of the video analyzed, a distribution of A:T ratio can be generated.

Problems/Future Goals

Problems:

- Estimating BCS for all types of dog breeds require large data set for training.
- The stats-based approach uses the highest standard deviation from the center point M, to determine R1 and R2, which may not always be accurate.
- The center of the image is not always the center of the dog with the stats-based approach.

Future Goals:

- Improve the current approaches to generating an A:T ratio, to generate a more accurate BCS score. (Accurate)
- Make sure the model performs well across various breeds of dog with different features. (Robust)
- Upload all data onto a scholar directory as it has more space than a student's laptop. (Scalable)

Conclusion/Acknowledgements

Conclusion:

The team tried many methods to determine an AT ratio, to determine A BCS score. These three were the most successful:

- DeepLabCut:** Using deep neural network to track body parts.
- Stats-based:** Using standard deviation of column sums.
- Sobel operator:** Using kernels to extract features.

Acknowledgements:

The team would also like to thank Dr. Troy Hawkins and Dr. Amy Reibman for their help as mentors throughout this project!

The team would also like to acknowledge former members who helped with the project: Daniela Chanci Arrubla, Juan Antonio Barragan, Kourtney Masterson, and Emily Moritz.

References:

- <https://raleighncvet.com> (formal BCS definition)
- [Can you Estimate Body Composition in Dogs from Photographs?](#) (paper on BCS in dogs)
- [Mathis, A. et al. \(2018\)](#) (paper on DeepLabCut)

App Introduction

In the transition from the Fall 2020 semester into the Spring 2021 semester, one of the team's biggest goals was to develop an Android application that will determine the A:T ratio and thus the Body Condition Score (BCS) of a dog.

To accomplish this, the team split into three workstreams:

- **The frontend**, which designed the app/user interface.
- **The backend**, which was responsible for receiving the images and automating code for image processing.
- **The app**, which was responsible for creating the working app from the frontend's interfaces.

This poster focuses on each workflow's methods to create an Android application prototype.

Frontend Workstream (Leader: Erin Johnson)

This team is focused on the design of the user interface of the Elanco BCS Scorer app. The frontend helped to design and develop the interfaces for the following pages using Android Studio:

- Start pages
- Camera interface
- Instructional page
- Error page
- Results platform



The Elanco BCS Scorer app logo

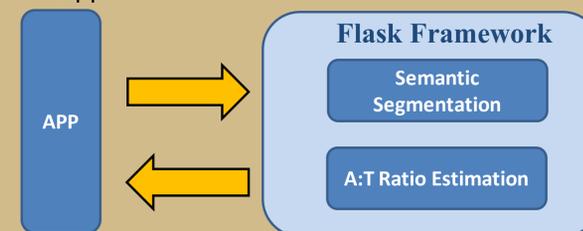


The Elanco BCS Scorer app icon

Backend Workstream (Leader: Zhiwen Cao)

This team is focused on the backend calculations, such as using Semantic Segmentation to get A:T lines and dividing them to get an A:T ratio from an input picture.

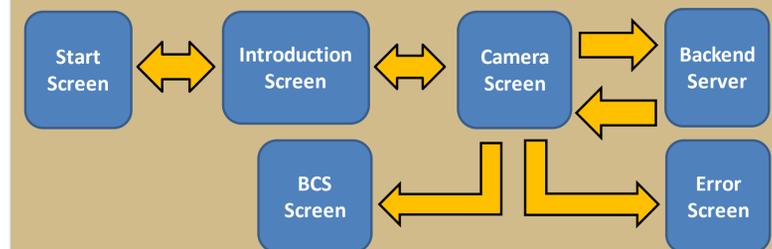
Flask – Python framework that allows us to output BCS scores and any calculation errors after an image is input from the application.



The above figure shows the backend framework. A photo is sent from the app to the backend Flask framework where an A:T estimation is calculated and sent back to the app.

App Workstream (Leader: Yubo Shao)

This team is focused on building an Android App which implements a custom camera to take a dog image, transfer the image to the backend server through Flask for BCS classification, and display either the BCS score or an error message.



The above figure shows the flowchart of our Android App's basic functionality for calculating BCS from dog images. Once the user takes a dog image, the Android App will connect with the server end based on a specific IP address through Flask and transfer the image to the server end.

Problems/Other Attempts

Frontend: using a splash screen orientation to cycle through interfaces didn't allow for the user to be able to navigate through the app easily, so we transitioned to using a start screen instead.

Backend: mobile devices cannot run large neural network, so we built a server end which can run our machine learning model in a better performance.

App: using the in-built camera app did not allow us to transfer the image to the server automatically, so we created a custom camera instead.

Conclusion/Future Developments

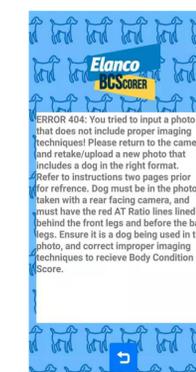
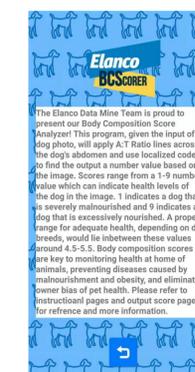
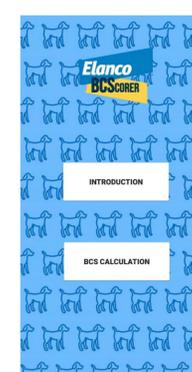
Conclusion:

In conclusion, the three workstreams were able to create a BCS Scorer app prototype. While there is still much that could be accomplished through these interactive pages, this is the most basically applied method to encode a functioning calculator.

Future Developments:

- Create server-based user interactions for application, including user profile, pets, and saved progress tracking
- More defined user error page
- Functionality to identify breeds of dog and accordingly match a BCS distribution
- Let user either takes an image or uploads an image for BCS calculation
- Take video/sequence of images as input such that it gives more accurate BCS estimation
- Create a version for IOS devices and computer systems.

App/User Interface



The above interfaces, from left to right show the start page, a page with an instructions button and a BCS Calculator button which takes one to the camera, an instructions page, an error page if an image cannot be processed, two camera pages (one to take the picture and one to confirm the picture), and a results page that shows a dog's BCS score and a chart showing what that score means.

Acknowledgements:

The team would like to thank Dr. Troy Hawkins and Dr. Amy Reibman for all their help as mentors throughout this project!