Homework 1

Yue Jiang

STA 440 / Spring 2025

Introduction

Subagia, Saleh, Churchwell, and Zhang (2020) aimed to examine potential associations between the configuration of helicopters and the odds of experiencing an accident, using logistic regression methods on a dataset of over 800 accidents among approximately 8,000 helicopters between 2005 and 2015.

RESEARCH ARTICLE

Statistical learning for turboshaft helicopter accidents using logistic regression

Rachmat Subagia, Joseph Homer Saleh*, Jared S. Churchwell, Katherine S. Zhang

School of Aerospace Engineering, Georgia Institute of Technology, Atlanta, Georgia, United States of America

* joseph.saleh@aerospace.gatech.edu

Logistics

Note that this homework assignment is due **Friday, January 31** and graded on accuracy, to be turned in on Gradescope (no need to make a repository or anything).

This is an individual assignment; you are not allowed to work with any other students, though you are allowed to use any existing resources (books, notes, internet resources, etc.), or AI tools in accordance with the class policy.

By submitting this assignment, you pledge to uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

Logistics (part 2)

The link to the study is here and is also provided in the course GitHub repository here (feel free to skim it; you don't need to read the entire thing carefully!).

There are a total of **five questions**, found on the following pages. The homework assignment is based on **Table 3** (question 1) and **Table 5** (questions 2 - 5).

Exercise 1

This question is related to **Table 3**, which reproduced below. Note that Table 3 includes results from four different models:

Table 3. Results of fitting univariate logistic regression model in the turboshaft helicopter data (one covariate at a time).

Variable	Estimated Coeff. ($\hat{\beta}$)	Standard Error ($\widehat{SE}$)	*z*	*p*-value	$\widehat{OR}$	95% CI of $\widehat{OR}$
N_BLADES						
N_BLADES1	-0.543	0.089	-6.10	<0.001	0.58	0.49–0.69
N_BLADES2	0.281	0.106	2.64	0.008	1.32	1.08–1.63
N_BLADES3	-0.416	0.273	-1.52	0.127	0.66	0.39–1.13
N_ENGINES	-0.723	0.103	-7.00	<0.001	0.49	0.40–0.59
ROTORDIA	-0.061	0.006	-9.62	<0.001	0.94	0.93–0.95
MTOW	-0.096	0.012	-8.25	<0.001	0.91*	0.89–0.93

OR, Odds ratio; CI, Confidence Interval

* OR for 1,000 pounds (455 kg) increase in MTOW

- (a) Interpret the estimated odds ratio corresponding to `N_BLADES3`. Do not use raw variable names as the authors do, but rather express your interpretations in the context of what the variables represent (i.e., in plain English). What might you conclude at the $\alpha = 0.05$ significance level?
- (b) Do the same as the above for `MTOW`.

Table 5

Table 5. Final model of turboshaft helicopter accidents with statistical interactions.

	x	Estimated Coeff. ($\hat{\beta}$)	Standard Error ($\widehat{SE}$)	*z*	*p*-value	95% Confidence Interval	
N_BLADES							
N_BLADES1	$x_{1,1}$	-0.390	0.118	-3.29	0.001	-0.622	-0.158
N_BLADES2	$x_{1,2}$	0.792	0.245	3.24	0.001	0.313	1.272
N_BLADES3	$x_{1,3}$	0.879	0.447	1.97	0.049	0.003	1.755
N_ENGINES	x_2	-3.179	0.937	-3.39	0.001	-5.016	-1.343
ROTORDIA	x_3	0.264	0.084	3.13	0.002	0.099	0.430
MTOW1*	x_4	1.836	0.470	3.91	<0.001	0.915	2.758
MTOW2**	x_5	-0.081	0.022	-3.66	<0.001	-0.124	-0.038
N_BLADES×N_ENGINES							
N_BLADES1×N_ENGINES	$x_{6,1}$	0.147	0.304	0.48	0.628	-0.448	0.742
N_BLADES2×N_ENGINES	$x_{6,2}$	-1.265	0.447	-2.83	0.005	-2.142	-0.388
N_BLADES3×N_ENGINES	$x_{6,3}$	-1.304	0.845	-1.54	0.123	-2.960	0.351
N_ENGINES×ROTORDIA	x_7	0.083	0.022	3.79	<0.001	0.040	0.126
ROTORDIA×MTOW1*	x_8	-0.050	0.012	-3.99	<0.001	-0.075	-0.025
ROTORDIA×MTOW2**	x_9	0.002	0.0004	4.33	<0.001	0.001	0.003
Constant	$(x_0 = 1)$	-11.147	2.839	-3.93	<0.001	-16.712	-5.582

* MTOW1 is a scaled MTOW with power 0.5 (MTOW1 = $(\text{MTOW}/100)^{0.5}$)

** MTOW2 is a scaled MTOW with linear term (MTOW2 = MTOW/100)

Exercise 2

Format **Table 5** more professionally by correcting the following:

- The variables are not written professionally (do not use raw variable names as provided in R, but rather an English-language explanation of what they correspond to)
- There are columns which are essentially useless (e.g., the one labeled "x")
- There are columns which are extraneous (the z-statistic can be calculated directly from the estimate and associated standard error; the standard error estimate is only used to calculate the p-value and 95% CI, etc. What do people actually care about? Could an estimated coefficient and associated CI be enough? etc.)
- There are inconsistencies in the number of decimal places reported; for those instances in which the decimal point is below the lowest accuracy provided (e.g., if you have to write something like "0.000,"), instead report it being lower than the number of decimal points chosen (e.g., "<0.001").
- It is not clear what the units are (if applicable)

Your corrected table should be **on the odds ratio scale**, not log-odds.

Exercise 3

In Table 5, quantify any relationships between the number of engines and helicopter accidents. Do so in a way that makes the most sense in context of the original data and express relationships on the odds ratio scale.

Exercise 4

Are there any circumstances in which increased maximum takeoff weight is associated with *lower* predicted odds of accidents according to the model in **Table 5**? If so, specifically identify all such cases; if not, explain why not. Show your work (the authors attempt to do this using Fig. 5, but there's room for improvement).

Exercise 5

Evaluate the following statement from the authors regarding the goodness-of-fit for the model in Table 5 (pp. 10-11). Is the statement appropriate? Explain why or why not (you may assume that the statistical test itself is fine to use).

> *"The goodness-of-fit test ... obtains that the p-value computed ... is 0.3317. Therefore, the null hypothesis that the probability of accidents in each group between estimated and observation data is similar cannot be rejected. In other words, a comparison of the observed versus expected frequencies in each group shows close agreement."*