Assignment: Statistical Investigation

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1. Finding and processing the data.

   (a) Find the release date and the number of parameters of the n = 6 following models: ELMo, GPT-2, Megatron LM, Turing NLG, GPT- 3, and (very recent) Megatron-Turing NLG. Record the dates and number of parameters in a table for each model $i \in \{1, \ldots, n\}$. Discuss which sources you used and how you understood release date and number of parameters. Discuss data quality.

Name	Release Date	# of parameters
ELMo	2018	93.6 Million
GPT-2	February 14, 2019	1.5 billion
Megatron LM	September 17, 2019	8.3 billion
Turing NLG	February 13, 2020	17 Billion
GPT-3	June 11, 2020	175 billion
Megatron-Turing NLG	October 11, 2021	530 Billion

Table 1: Release Date and number of parameters

https://allenai.org/allennlp/software/elmo
https://arxiv.org/abs/1805.06556
https://www.researchgate.net/figure/Parameter-configuration-of-ELMO_tbl2_349764218

https://en.wikipedia.org/wiki/GPT-2

https://arxiv.org/abs/1909.08053

https://www.microsoft.com/en-us/research/blog/turing-nlg-a-17-billion-parameter-language-model-by-microsoft/

https://en.wikipedia.org/wiki/GPT-3

https://www.microsoft.com/en-us/research/blog/using-deepspeed-and-megatron-to-train-megatron-turing-nlg-530b-the-worlds-largest-and-most-powerful-generative-language-model/

   (b) Prepare a scatter plot with time as horizontal axis and number of parameters as vertical axis.
   Check scatterplot.png

   (c) How can you represent the release dates for each model as continuous variable x_i? Decide and record the values of x_i and the logarithm to the basis 10 of the number of parameters (let's call those values y_i) for each model $i \in \{1, \ldots, n\}$ in a second table.

   (d) Prepare a scatter plot with time x_i as horizontal axis and the logarithm to the basis 10 of the number of parameters y_i as vertical axis.
   Check scatterplot_log.png

X_i	Y_i, $Y_i = \log_{10}(X_i)$
$X_1 = 2018$	$Y_1 = -1.028\ldots$
$X_2 = 2019$	$Y_2 = 0.176\ldots$
$X_3 = 2019$	$Y_3 = 0.919\ldots$
$X_4 = 2020$	$Y_4 = 1.230\ldots$
$X_5 = 2020$	$Y_5 = 2.243\ldots$
$X_6 = 2021$	$Y_6 = 2.72\ldots$

Table 2: Release Date and log of number of parameters

(e) Are there any visual outliers?

Yes, GPT-3 is quite a outlier, which isn't weird, it was a huge deal in the world of AI models.

2. Fitting a linear model..

(a) A simple regression model postulates relation between explained variable (logarithmic model size yi) and explanatory variable (time xi)

$$y_i = \alpha + \beta x_i + \epsilon_i \tag{1}$$

Explain why the exponential growth hypothesis suggest such a model.

If the relationship is presumed exponential and you take the log of the explanatory variable , then the curve goes from exponential to straight, because log(exp(x)) == x. That way you can fit a linear model instead of an exponential.

(b) Perform a regression to find estimates for α and β

(c) Add the regression line to the scatter plot of 1d.

(d) Prepare a scatter plot of the residuals. Does the model give a good fit? Discuss model validation.

(e) Add the curve corresponding to the regression line in 1d to the scatter plot of 1b.

(f) Give an interpretation of the slope: how many years does it take for parameter number to increase by a factor of 10 in terms of β?

3. Making predictions.

(a) Is there any significant linear relation between the logarithmic parameter number and time? Formulate a null hypothesis and test at significance level 0.05. Assume normal errors with unknown variance σ^2.

(b) Find a 95% confidence interval for the slope. Use it to determine a 95% confidence interval for the length of time in which the model parameter number tends to increase by a factor of 10.

(c) What model size can we expect for models in next spring (April 2023)? Give a 95% confidence interval. Let's see if that comes true...

(d) What do think: Will the model make a reasonable prediction of model size in 2030?