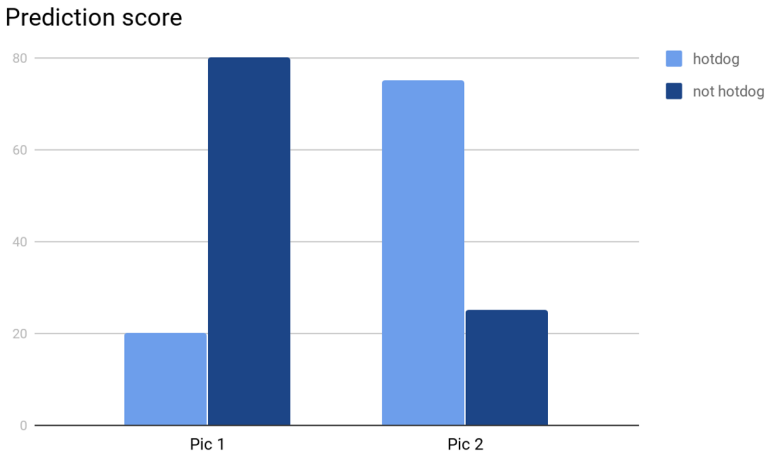
Confidence

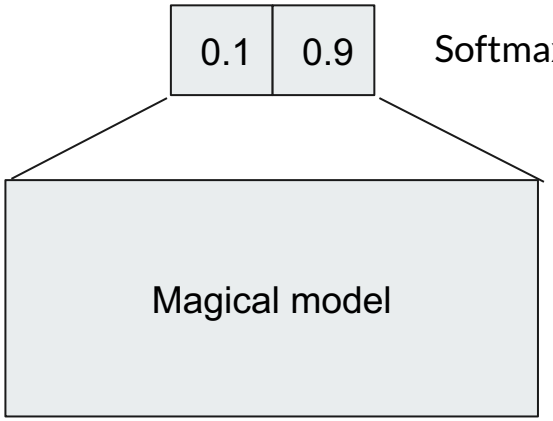
Confidence score

Practical models are not only accurate, but need to be able to state its confidence

Confidence = probability of being correct

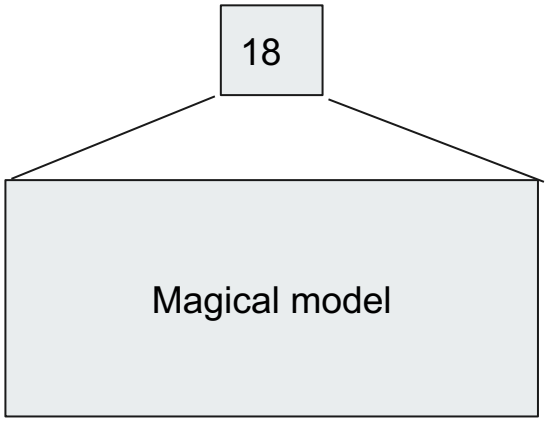


Naive way for confidence



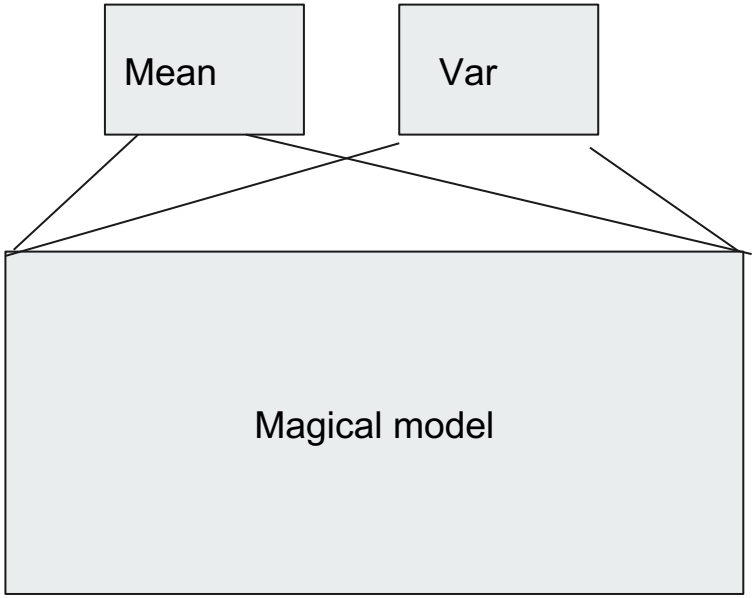
Confidence level = 0.9?

What about regression?



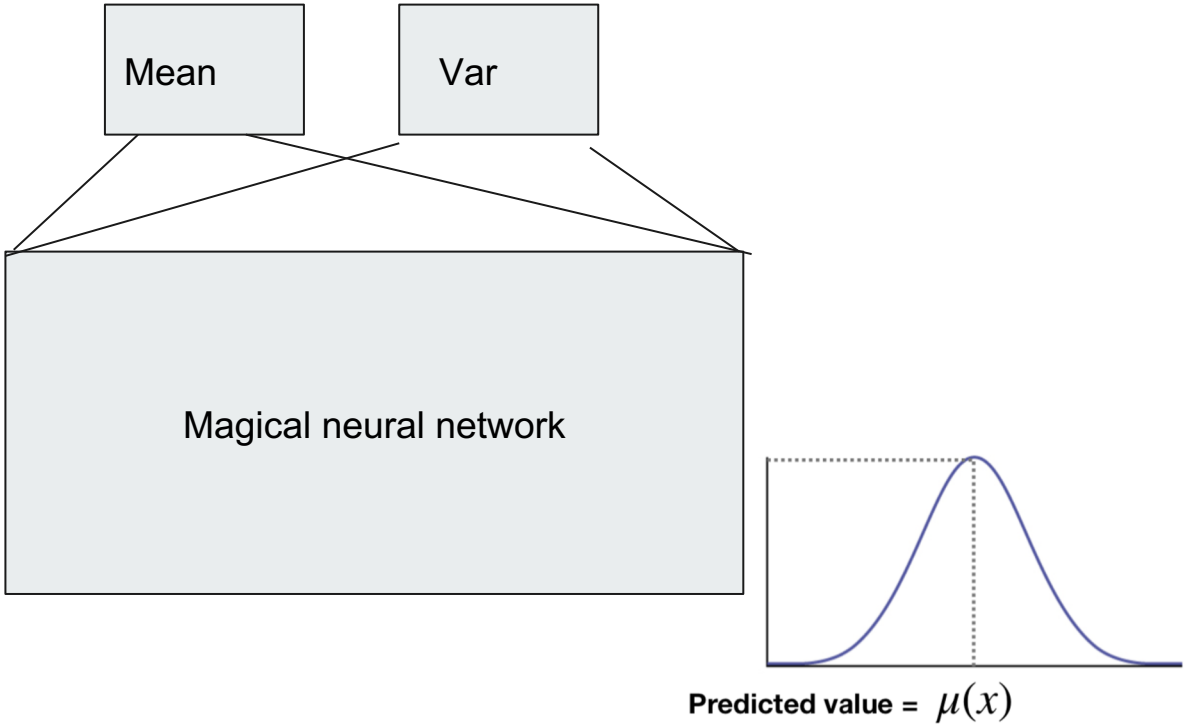
Confidence level = ???

A Naive way for regression (1994!)



Estimating the mean and variance of the target probability distribution. IEEE 1994

A Naive way for regression (1994!)

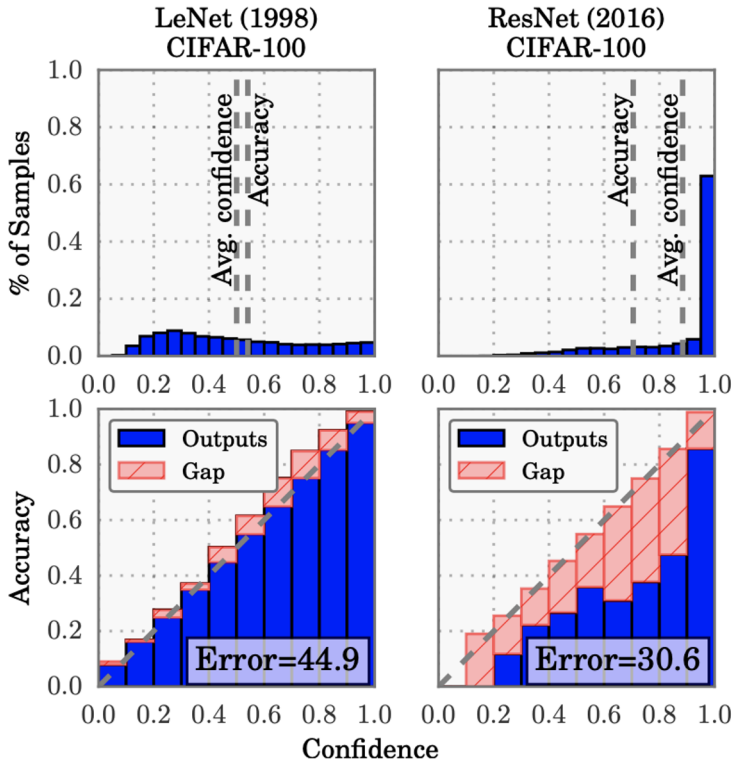


Estimating the mean and variance of the target probability distribution. IEEE 1994

Poorly calibrated confidence

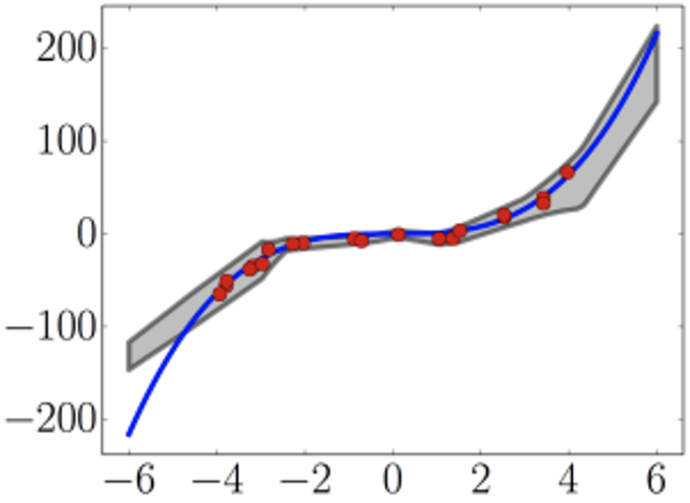
Deep Neural Networks are always overconfident!

Confidence = Probability of being correct

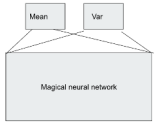


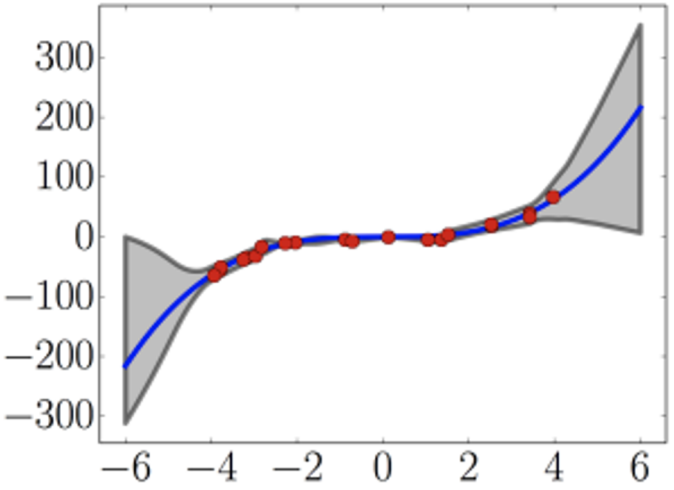
On Calibration of Modern Neural Networks JMLR 2017

Out of distribution problem



output from predicting variance via maximum likelihood





output from ensemble

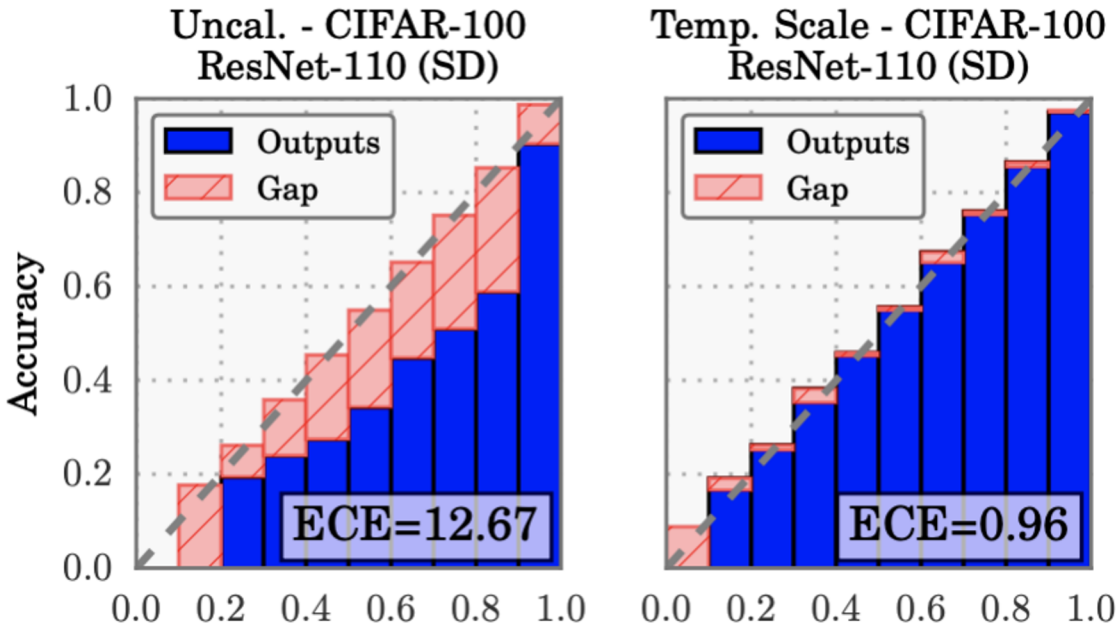
Simple and scalable predictive uncertainty estimation using deep ensembles. 2017

Neural network calibration

Make the confidence output follows the probability of being correct.

How?

Need a seperate training set to train the calibration (calibration set)



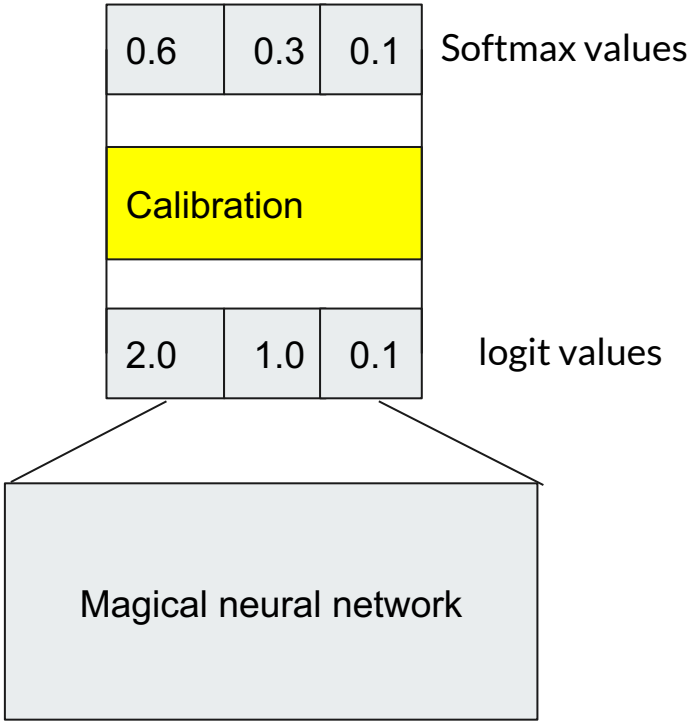
Overview of methods for calibration

1 Calibration

2 Ensemble

Calibration

Post processing after getting pre-softmax output (logit)



Calibration - Temperature scaling

Add a temperature T to rescale the softmax

$$\hat{q}_i = \max_k \sigma_{\mathrm{SM}}(\mathbf{z}_i / T)$$

T is tuned to maximize log likelihood on the calibration set

Low T

High T

https://arxiv.org/pdf/1611.01144.pdf

Other calibration methods

Histogram binning
Bayesian binning into quartiles (BBQ)
Matrix and vector scaling (model on top of model)
Isotonic regression (model on top of model)

Try different methods on your dataset. No absolute best.
https://scikit-learn.org/stable/modules/calibration.html

Model ensemble for variance estimation

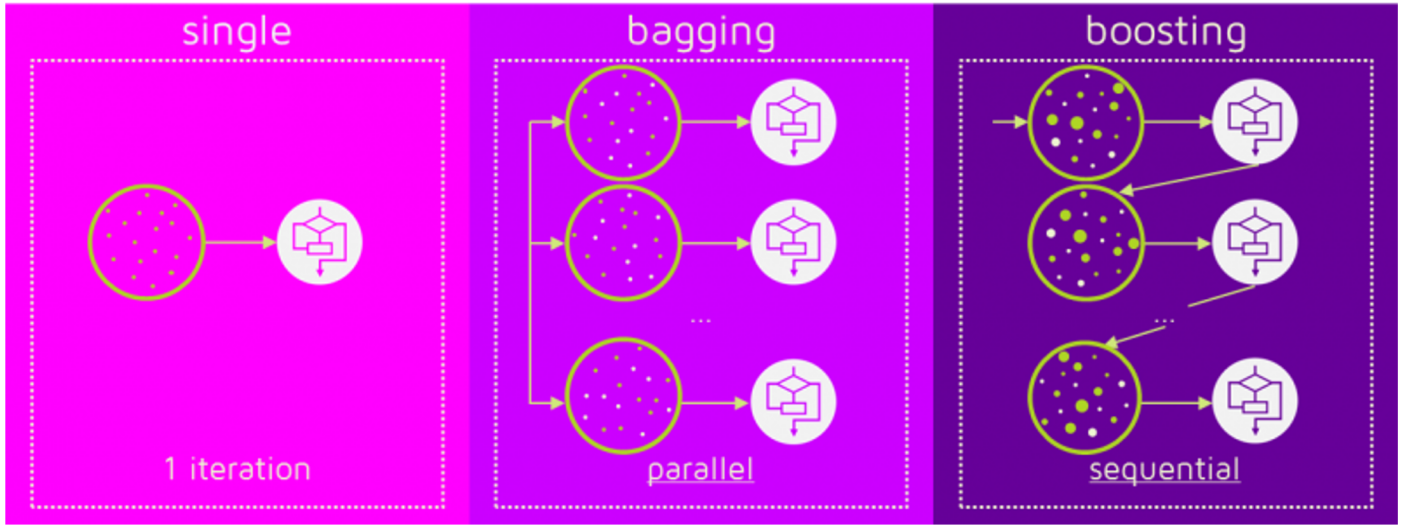
Intuition: if you have two independent experts, if they agree you can be confident about their judgement

Model ensemble for variance estimation

1. Train multiple models and have them predict the same input.
2. Calculate the mean and variance of the prediction
3. The confidence can be from calculating the area under the Gaussian pdf

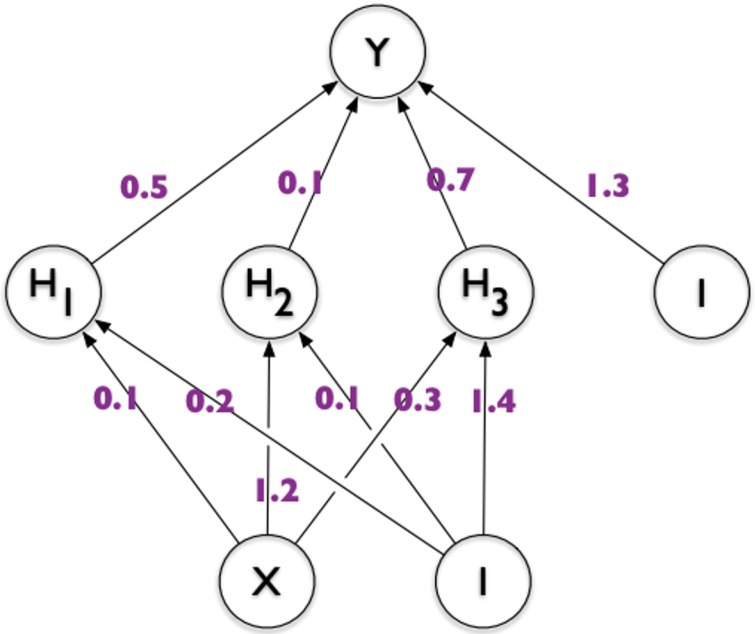
Training multiple models?

Random forest are inherently random. Training the model multiple times will give different models.

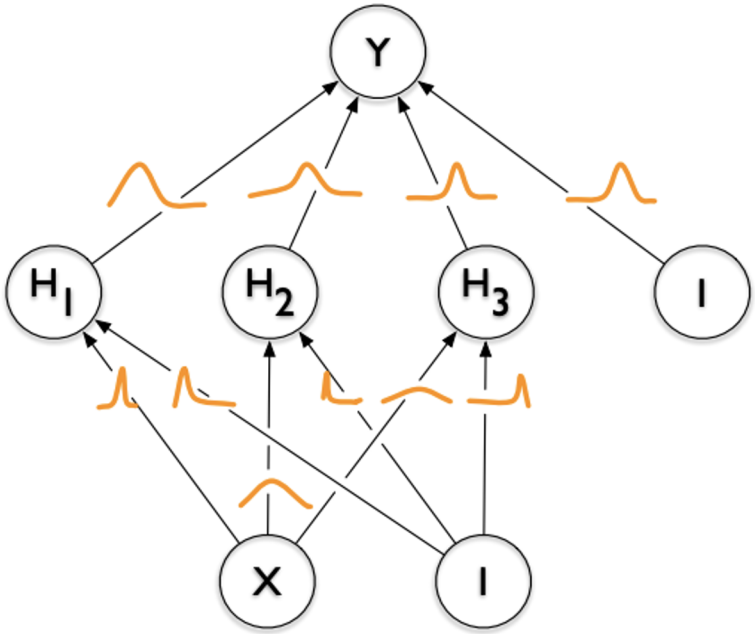


Bayesian Neural Network

Normal NN



Bayesian NN

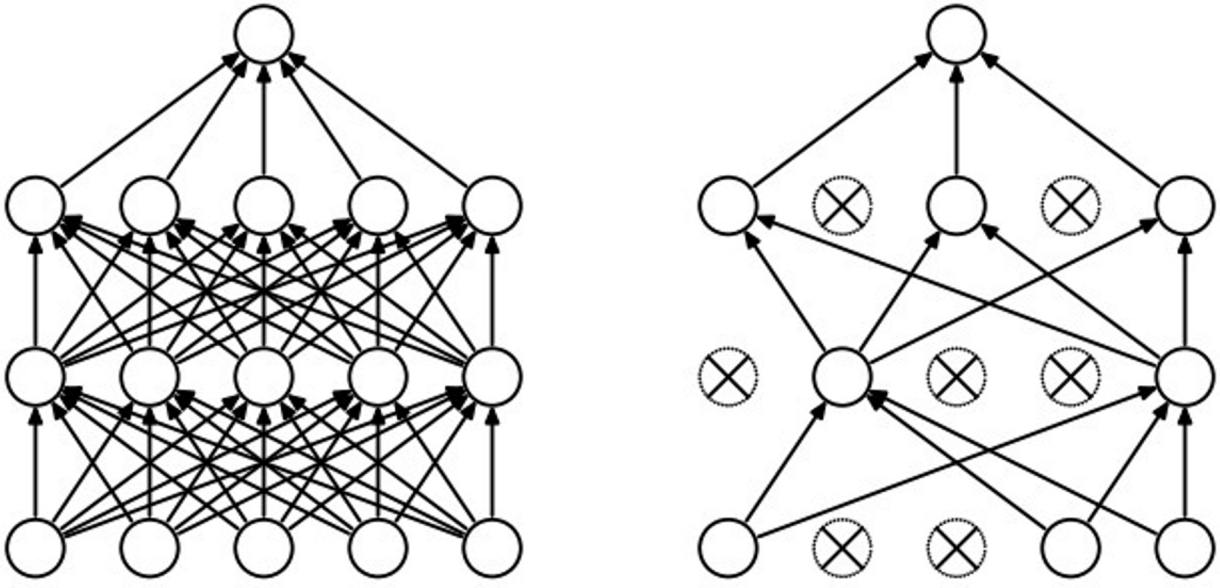


Problem: hard to do inference. Need to find $P(y \mid x, D) = \sum_{\theta} P(y \mid x, \theta) P(\theta \mid D)$

Weight Uncertainty in Neural Network. ICML 2015

Training multiple models

Dropout can be used for creating multiple prediction from one neural network model



(a) Standard Neural Net

(b) After applying dropout.

Monte Carlo dropout for confidence estimation

compute mean and variance for the answer and confidence

20.2 +- 3.2

25 27 18 15