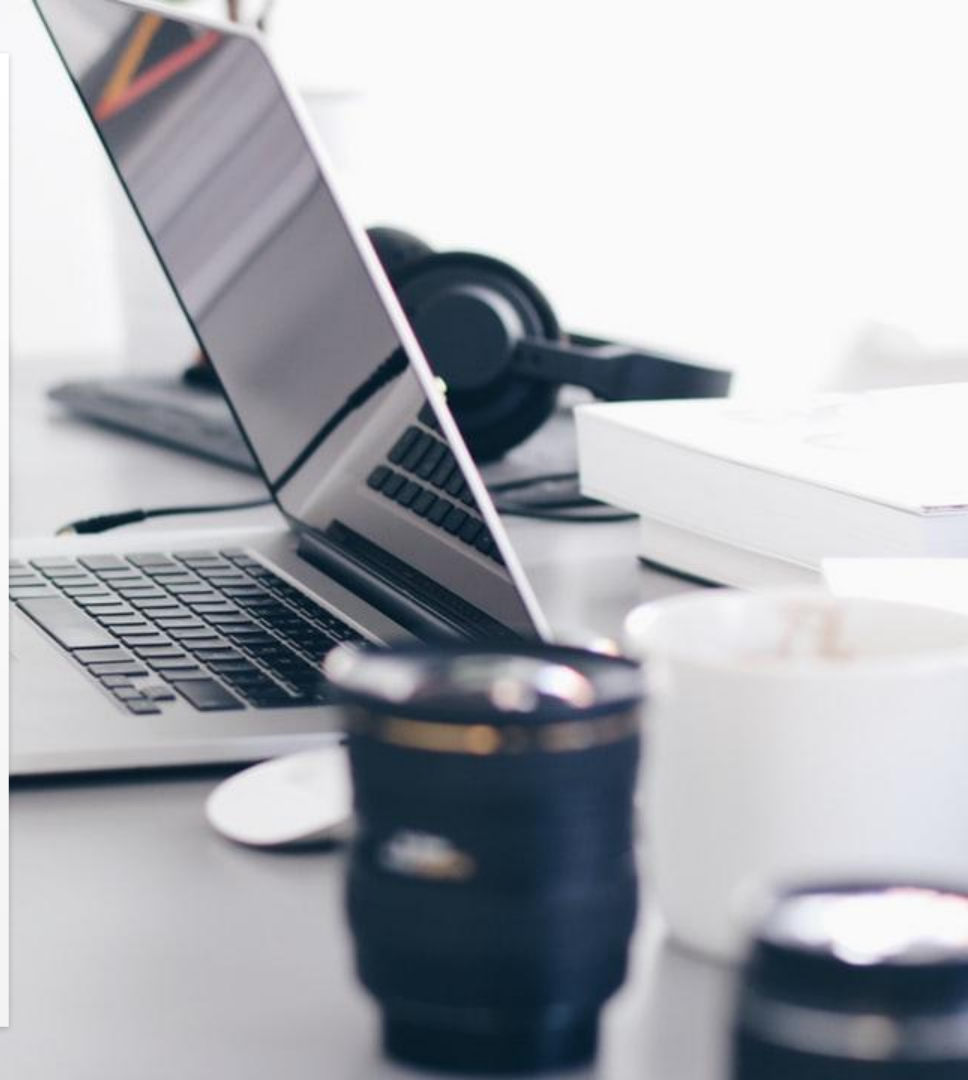
Kaggle Competition: Severstal Steel Defect Detection Challenge



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Introduction

Problem Statement

"...predicting the location and type of defects found in steel manufacturing. Images are named with a unique `ImageId`. You must **segment and classify the defects** in the test set."

Severstal Steel Defect Kaggle Competition Excerpt

*(*https://www.kaggle.com/c/severstal-steel-defect-detection/data*)*

Evaluation Metric and Dataset

Evaluation Metric

The Dice Coefficient was used in the competition as the evaluation metric for a submitted model's accuracy.

$$\frac{2 * |X \cap Y|}{|X| + |Y|}$$

Dataset

1. Unique ImageId
2. Defect Class
3. Encoded Pixels

ImageId	ClassId	EncodedPixels
0002cc93b.jpg	1	29102 12 29346 24 29602 24 29858 24 3011
0007a71bf.jpg	3	18661 28 18863 82 19091 110 19347 110 19
000a4bcdd.jpg	1	37607 3 37858 8 38108 14 38359 20 38610
000f6bf48.jpg	4	131973 1 132228 4 132483 6 132738 8 1329
0014fce06.jpg	3	229501 11 229741 33 229981 55 230221 77

Challenges of the Problem

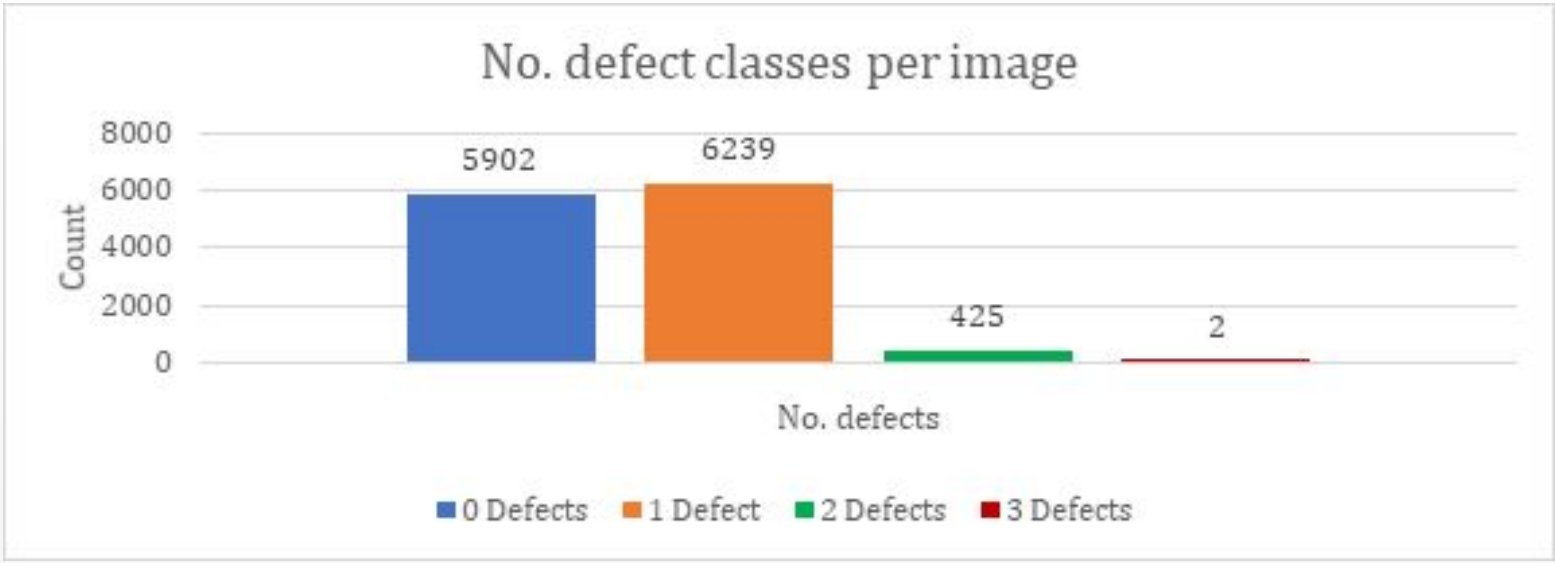
01	**Imbalanced Dataset**	• No Defects: 5902 • Defect Class 1: 897 • Defect Class 2: 247 • Defect Class 3: 5150 • Defect Class 4: 801
02	**Complex Problem**	• Segmentation • Classification
03	**Lack of Domain Knowledge**	• Defects are physically visible • Some defect types can be distinguished from one another
04	**Competitive Leaderboard**	• 46, 564 Submissions • The top 126 submissions varied only from 0.90X

Data Description

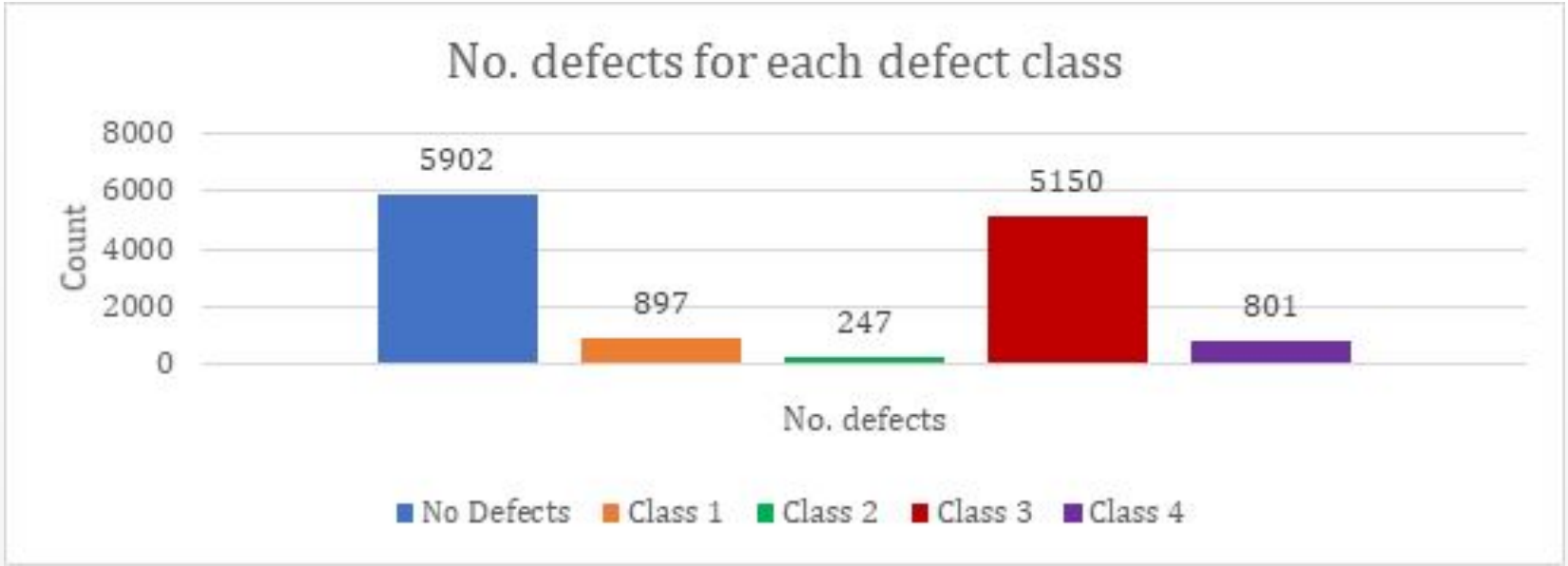
Train and Test Dataset

- 12, 568 Labeled Images (Training Set)
- 5, 506 Unlabeled Images (Testing Set)
- 1620 x 256 Resolution

Exploratory Data Analysis



Exploratory Data Analysis



Basic Pre-Processing

1. Horizontal Flip

- Images are mirrored horizontally
- Online instead of offline augmentation

2. Image Normalization

- Standard pixel values range from 0 - 255
- Large values slow down learning
- Re-scaled pixel values range from 0 to 1

Baseline private score: **0.88190**

Advanced Pre-Processing

1. Contrast-Limited Adaptive Histogram Equalization (CLAHE)

- Variant of AHE technique
- Used to improve contrast in images
- Reduces undesired noise amplification
- Decreased private score of **0.85954** (vs 0.88190)

2. Spatial Detrending

- Different from temporal detrending
- Used to remove spatial bias from images
- Address depth differences from measurement tools
- Decreased private score of **0.86551** (vs 0.88190)

3. Random Brightness & Contrast

- Randomizing of image brightness and contrast
- Encourages model to be trained for all conditions
- Decreased private score of **0.86359** (vs 0.88190)

4. Random Grid Shuffle

- Segments each image using a grid of fixed length
- Grid sizes are meant to contain only wanted pixels
- Assist model with identifying unique features
- Decreased private score of **0.86895** (vs 0.88190)

5. Random Rain

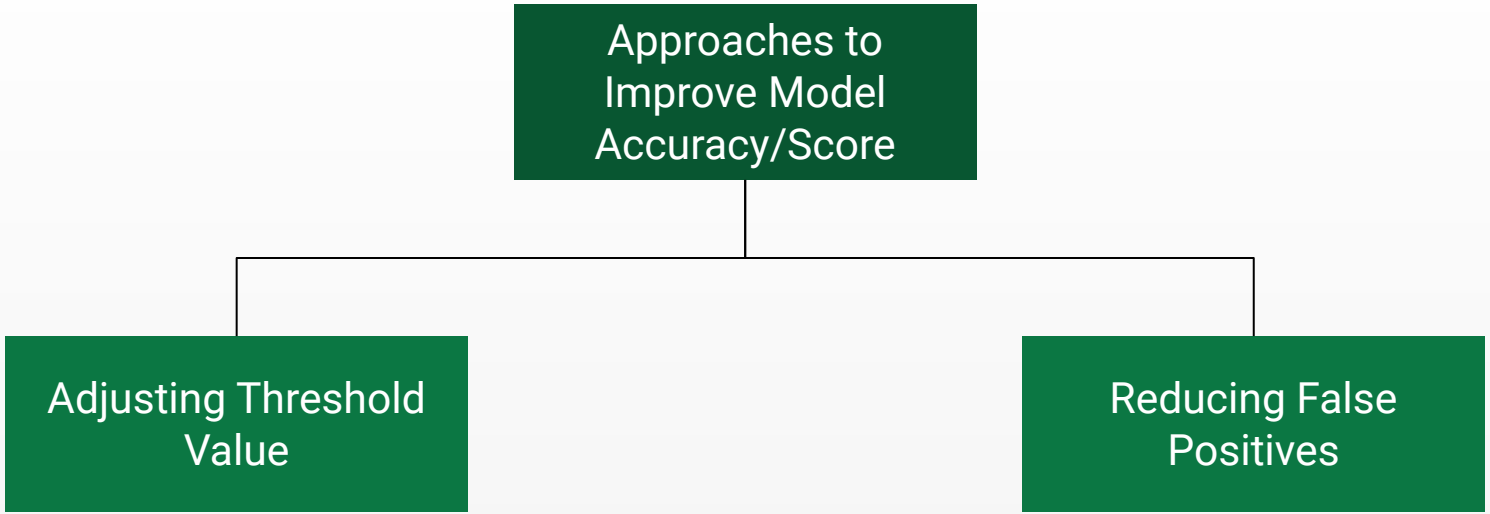
- Adds “rain” effect to images
- Training images similar to rain, long thin line strokes
- Train model to be better at identifying defects
- Decreased private score of **0.87347** (vs 0.88190)

6. Mask Dropout

- Similar to dropout regularization
- Random removal of masked regions
- More consistent private and public score
- Private: **0.87079**, Public: **0.86860**
- Decreased private score vs initial (0.86860)

Post-Processing

Approaches to Improve Score



Adjusting Threshold Value

Adjusting Threshold Value

Most Consistent Threshold Value: 0.919

Threshold Value	Non-Defect Images (%) Above Threshold	Defective Images (%) Below Threshold	TP	TN	FN	FP	Accuracy	Recall	Precision	F1
0.919	0.849373	0.873714	87.371388	84.937309	12.628612	12.529951	0.872594	0.873714	0.874577	0.874145

Reducing False Positives

Importance of Avoiding False Positives:

1. False Positives were heavily penalized.
2. Pixels misidentified as defects results in the score for the mask to be 0.
3. Pixels successfully identifying that there is no defect get a score of 1.

Approach to Reduce False Positive:

1. Minimum number of defective pixels > 3500.

Models

Residual Nets

- Utilizes skip connections to mitigate vanishing gradient problem seen in many deep networks.
- Performs better than a traditional network of the same depth.

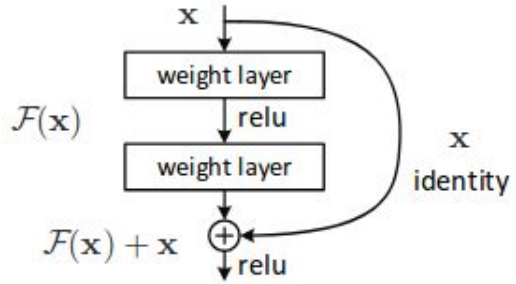


Figure 2. Residual learning: a building block.

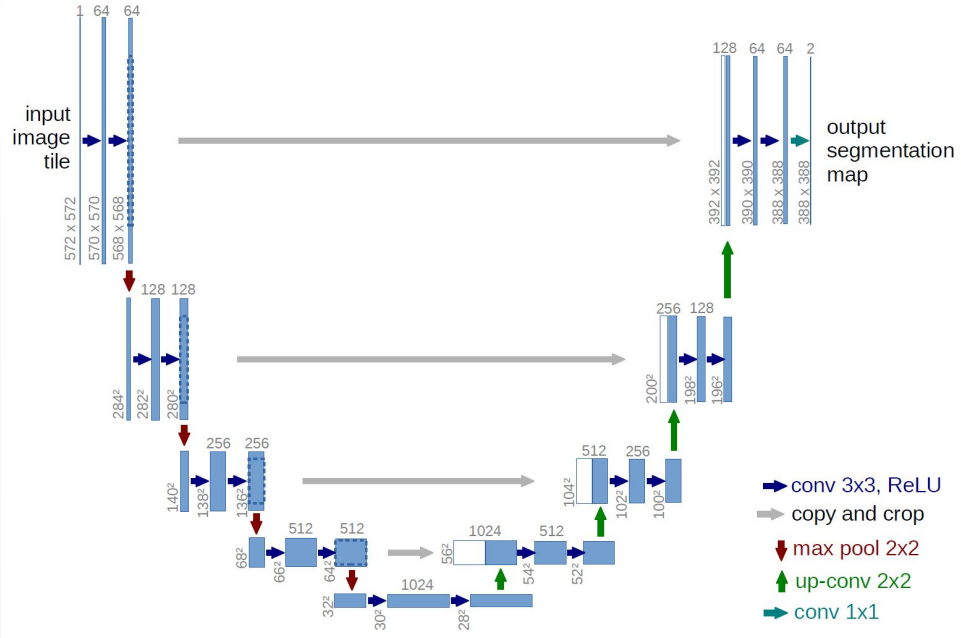
	plain	ResNet
18 layers	27.94	27.88
34 layers	28.54	**25.03**

Table 2. Top-1 error (%, 10-crop testing) on ImageNet validation. Here the ResNets have no extra parameter compared to their plain counterparts. Fig. 4 shows the training procedures.

UNet

Rationale: Excellent for Segmentation Tasks

Model Used: UNet with ResNet-18 Encoder



Summary

	Batch Size 4	Batch Size 8	Batch Size 12	Batch Size 14	Batch Size 16	Batch Size 18	Batch Size 20
ResNet-18	0.87678	0.87666			0.88190		
ResNet-34			0.85702	0.86433		0.86461	0.85334
ResNet-50		0.86068	0.86075				
ResNet-101	N.A	N.A	N.A	N.A	N.A	N.A	N.A
ResNet-152	N.A	N.A	N.A	N.A	N.A	N.A	N.A

What could have been done better

1. Adjusting the mitigation of False Positives
2. Use a deeper ResNet encoder
3. Fine tune pre-processing technique Random Grid Shuffle

Score and Ranking

Score: **0.88536**

Ranking: **1153**rd Position / **52.74**% Percentile

LB SCORE

LB RANK %

References

[1] G. Yadav, S. Maheshwari and A. Agarwal, "Contrast limited adaptive histogram equalization-based enhancement for real time video system," *2014 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, New Delhi, 2014, pp. 2392-2397.

[2] Neurohackweek.github.io. 2016. *Image Processing In Neuroimaging Applications : Detrending*. [online] Available at: <https://neurohackweek.github.io/image-processing/02-detrending/> [Accessed 27 April 2020].

[3] U. Saxena, "Automold--Road-Augmentation-Library," 28 November 2018. [Online]. Available: https://github.com/UjjwalSaxena/Automold--Road-Augmentation-Library.

[4] "Too much inputs = overfitting?," 24 June 2018. [Online]. Available: https://datascience.stackexchange.com/questions/33580/too-much-inputs-overfitting. [Accessed 1 May 2020].

[5] "What is translation invariance in computer vision and convolutional neural network?," 23 April 2016. [Online]. Available: https://stats.stackexchange.com/questions/208936/what-is-translation-invariance-in-computer-vision-and-convolutional-neural-netwo. [Accessed 1 May 2020].

[6] "What is translation invariance in computer vision and convolutional neural network?," 23 April 2016. [Online]. Available: https://stats.stackexchange.com/questions/208936/what-is-translation-invariance-in-computer-vision-and-convolutional-neural-netwo. [Accessed 1 May 2020].

[7] Ciresan, D.C., Gambardella, L.M., Giusti, A., Schmidhuber, J.: Deep neural networks segment neuronal membranes in electron microscopy images. In: NIPS. pp. 2852–2860 (2012)

[8] P. F. a. T. B. Olaf Ronneberger, "U-Net: Convolutional Networks for Biomedical Image Segmentation," arXiv, University of Freiburg, Germany, 2015.

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Bring the attention of your audience over a key concept using icons or illustrations

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Transition headline

Let’s start with the first set of slides

1

Quotations are commonly printed as a means of inspiration and to invoke philosophical thoughts from the reader.

This is a slide title

- Here you have a list of items
- And some text
- But remember not to overload your slides with content

Your audience will listen to you or read the content, but won’t do both.

Big concept

Bring the attention of your audience over a key concept using icons or illustrations

You can also split your content

White

Is the color of milk and fresh snow, the color produced by the combination of all the colors of the visible spectrum.

Black

Is the color of coal, ebony, and of outer space. It is the darkest color, the result of the absence of or complete absorption of light.

In two or three columns

Yellow

Is the color of gold, butter and ripe lemons. In the spectrum of visible light, yellow is found between green and orange.

Blue

Is the colour of the clear sky and the deep sea. It is located between violet and green on the optical spectrum.

Red

Is the color of blood, and because of this it has historically been associated with sacrifice, danger and courage.

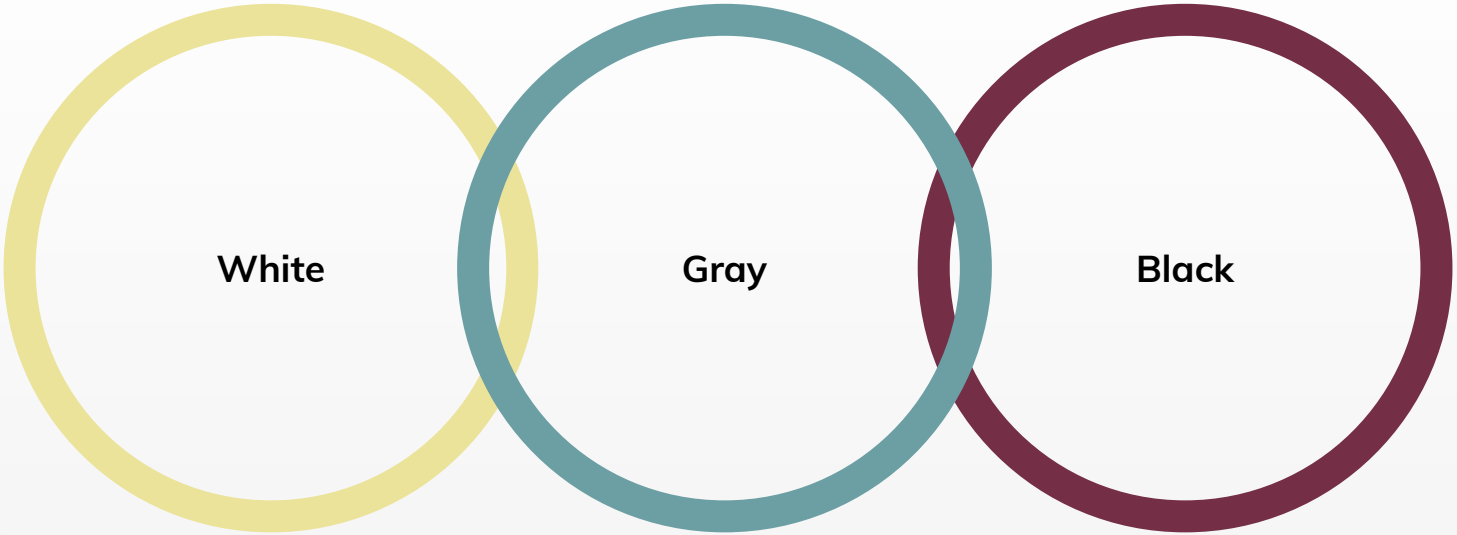
A picture is worth a thousand words

A complex idea can be conveyed with just a single still image, namely making it possible to absorb large amounts of data quickly.

Want big impact?

Use big image.

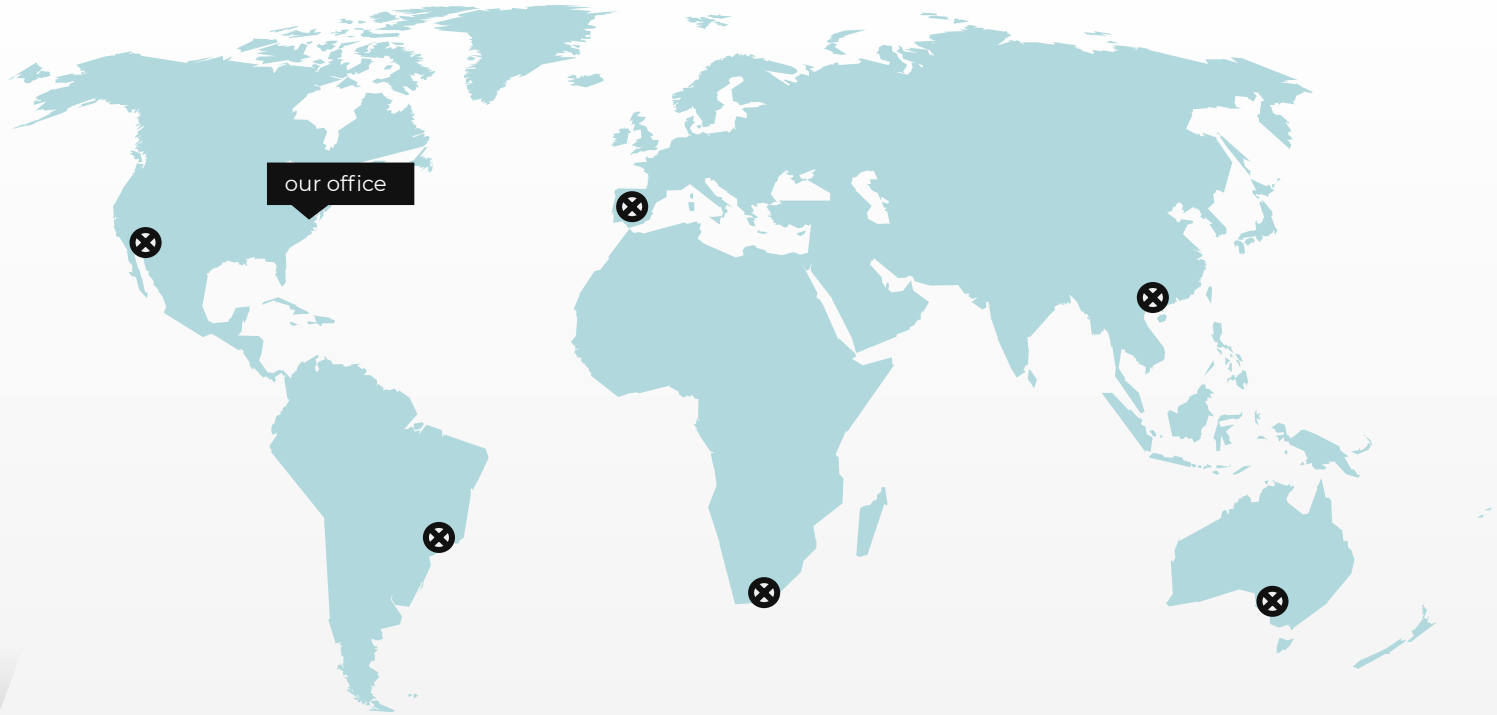
Use charts to explain your ideas



And tables to compare data

	A	B	C
Yellow	**10**	**20**	**7**
Blue	**30**	**15**	**10**
Orange	**5**	**24**	**16**

Maps



89,526,124

Whoa! That’s a big number, aren’t you proud?

89,526,124$

That’s a lot of money

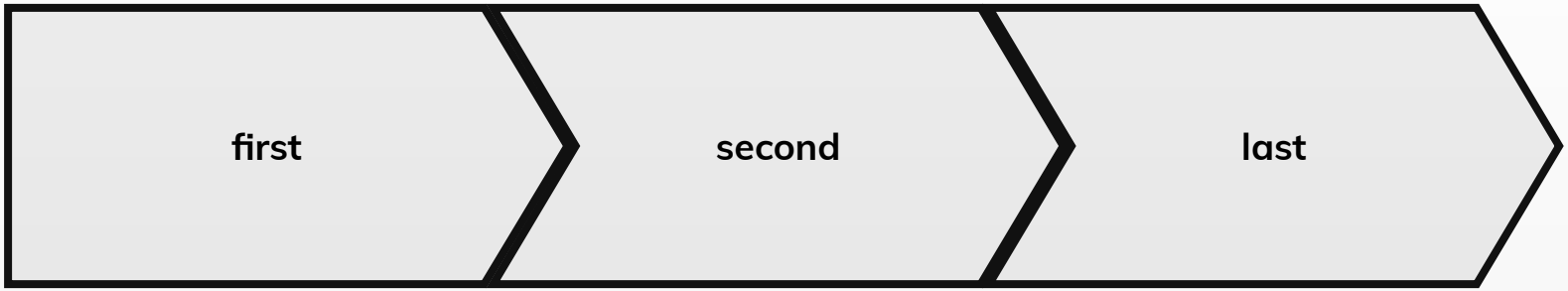
185,244 users

And a lot of users

100%

Total success!

Our process is easy



Let’s review some concepts

Yellow

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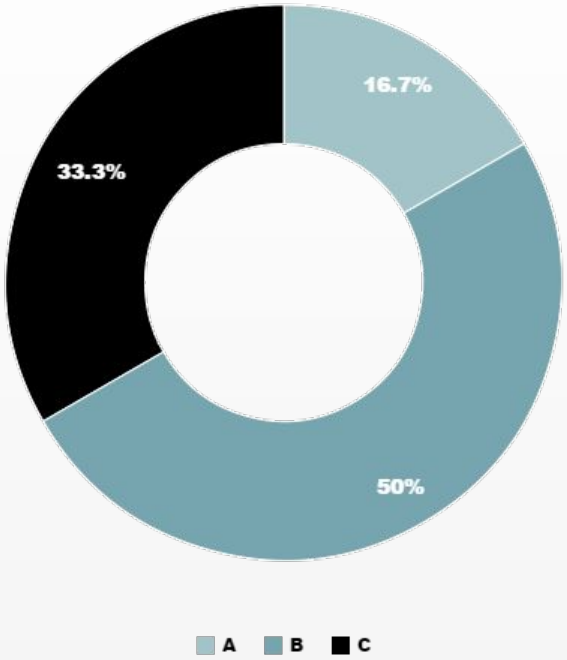

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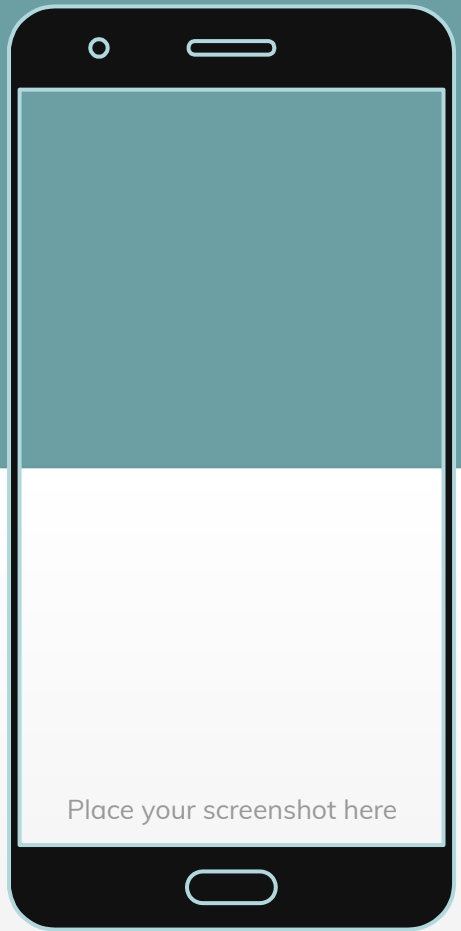

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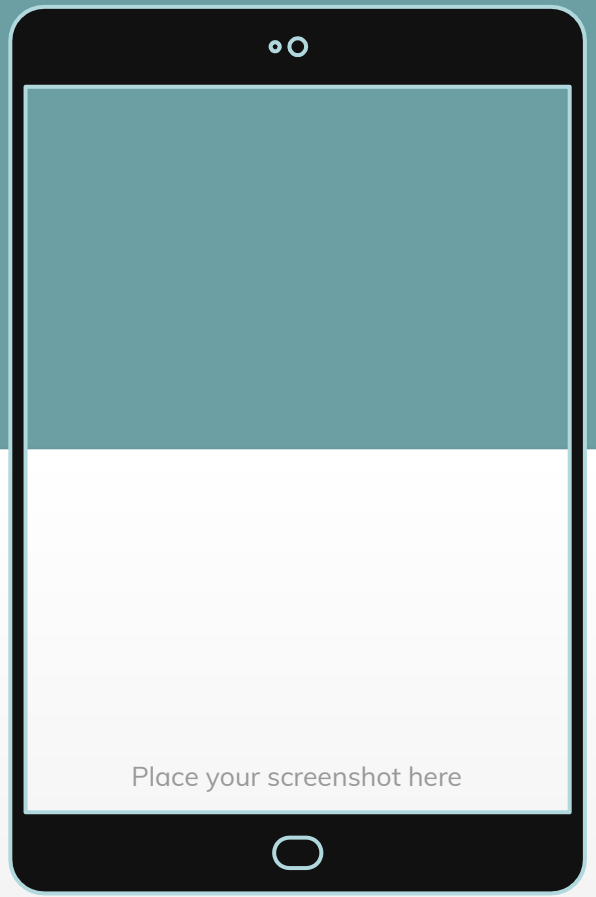

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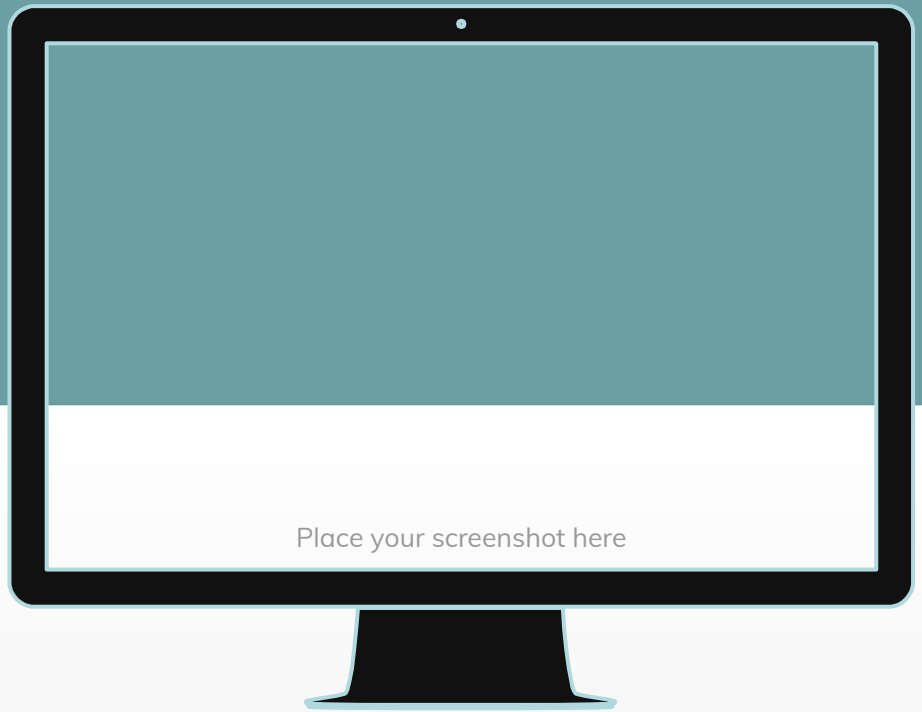

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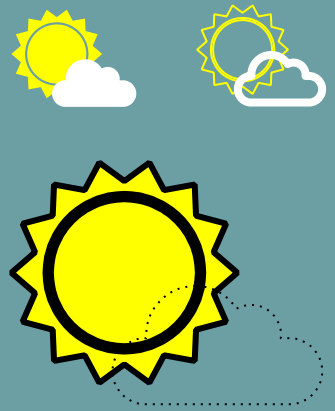

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