Intelligence without representation[1]

[1] Brooks, R. A. (1991). Intelligence without representation. Artificial intelligence, 47(1-3), 139-159.

Introduction

Why?

- Replicating human level intelligence in machine(s)

- In 1987 no one was talking about replicating the full gamut of human intelligence anymore

Introduction

Argument

- Incrementally build up capabilities
- Systems should interact in real world

Why:

- Representations get in the way, let the world be its own model
- Representations are wrong unit of abstraction

The evolution of intelligence

Evolution of intelligence

Timespans: [years]

- Primordial soup -> single cell
- Single cell -> photosynthetic plants [1 billion]
- Plants -> Fish, vertebrates [1.5 billion]
- Fish, vertebrates -> insects [100 million]
- Insects -> reptiles [80 million]
- Reptiles -> dinosaurs [40 million]
- Dinosaurs -> mammals [80 million]
- Mammals -> primates [130 million]

Human 2.5 million years ago

Agriculture 19k years ago

Writing 5k years ago

Expert knowledge last few hundred years

-> Behavior, language, expert knowledge simple after solving the essence of being and reacting

Example

- If aerospace engineers had been able to fly in our planes before inventing them they probably wouldn’t have.

Abstraction as a dangerous weapon

Self-deception

- When an algorithm developed by AI researchers successfully tackles an AI problem it isn't an AI problem after all (chess)

Abstraction as a dangerous weapon

Abstraction is biased

- “The only input to most AI programs is a restricted set of simple assertions deduced from real data by humans.”
- We still do most of the abstractions for the AI
- Does this not just make the ‘Merkwelt’ the same for AI and human?

Abstraction as a dangerous weapon

Two arguments against it

1. Each robot and each species has their own different Merkwelt. (A fly)
2. We base the Merkwelt on our own introspection. It is not clear at all whether that also is how our mind works. “... it could easily be an output coding for communication purposes (e.g. most humans go through life never realizing they have a large blind spot almost in the center of their visual fields)”.

Two arguments extended

1. Our idea of the Merkwelt may not be feasible with real sensors. It is too human-centric.
2. Even with human sensors and perception the Merkwelt may not be anything like we humans use or that our introspection is a correct reflection of what we use.

Incremental intelligence

Incremental intelligence

Creatures = agents

- Must cope with changes in its environment
- Should be robust wrt its environment
- Maintain multiple goals, change goals depending on circumstances
- It should have purpose

Approach

- Do not decompose by function but by activity
  - Each ‘layer’ connects sensing to action
  - Build simple complete autonomous system and **test in the real world** (e.g. robot that avoids hitting objects).

Approach: extended

- New layers can be added on top of previous layers that act in parallel:
  - First-level is unaware of second level, but second level can use intermediate first-level outputs
  - E.g. second layer forces creature to explore space, but is unaware that obstacles have to be avoided

Who has the representations

No representations

- Low-level layers can react to danger or important changes
- Without central representation, smaller chance of total collapse
- Each layer has an implicit purpose or goal
  - There need be no explicit representation of goals that are central (or distributed) to decide what to do next

Maxims

1. Needs to be tested in real world
2. Each layer must be tested extensively and be watertight -> bugs that arise in adding a new layer can only come from that layer

The methodology in practice

MIT AI laboratory mobots

layers:

1. Obstacle avoidance (static & dynamic)
2. Wander: when robot is not busy avoiding obstacles it generates a random heading every ten seconds
3. Explore: Looks for distant places and tries to reach them (suppresses wander layer)

What this is not

It isn’t many things

- Not connectionism (not one simple computation)
- Not neural networks, no biological significance in finite state machine
- Not German philosophy although it has similarities

Questions

- How many layers can be built before interactions become too complex?
- How complex can the behavior be that is developed without the aid of central representation?
- Can higher-level functions such as learning occur in fixed topology of simple FSM?

Limits to growth

Answers

- Maybe, not yet a problem
- Trying to build an empty can retrieving robot
- Yes, but in a way that was earlier scrutinized

Limits to growth

Future work

- Time will tell
- And maybe it has...?

Why not earlier?

- Mid-sized datasets such as ImageNet require an inductive bias in the model to get a good performance on
- Transformers do not generalize well when trained on mid-sized datasets

Thanks!

ANY QUESTIONS?

Let’s keep discussing the ideas and looking for ways to learn them deeper by applying them in unexpected ways

1

TRANSITION HEADLINE

Let’s start with the first set of slides

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.

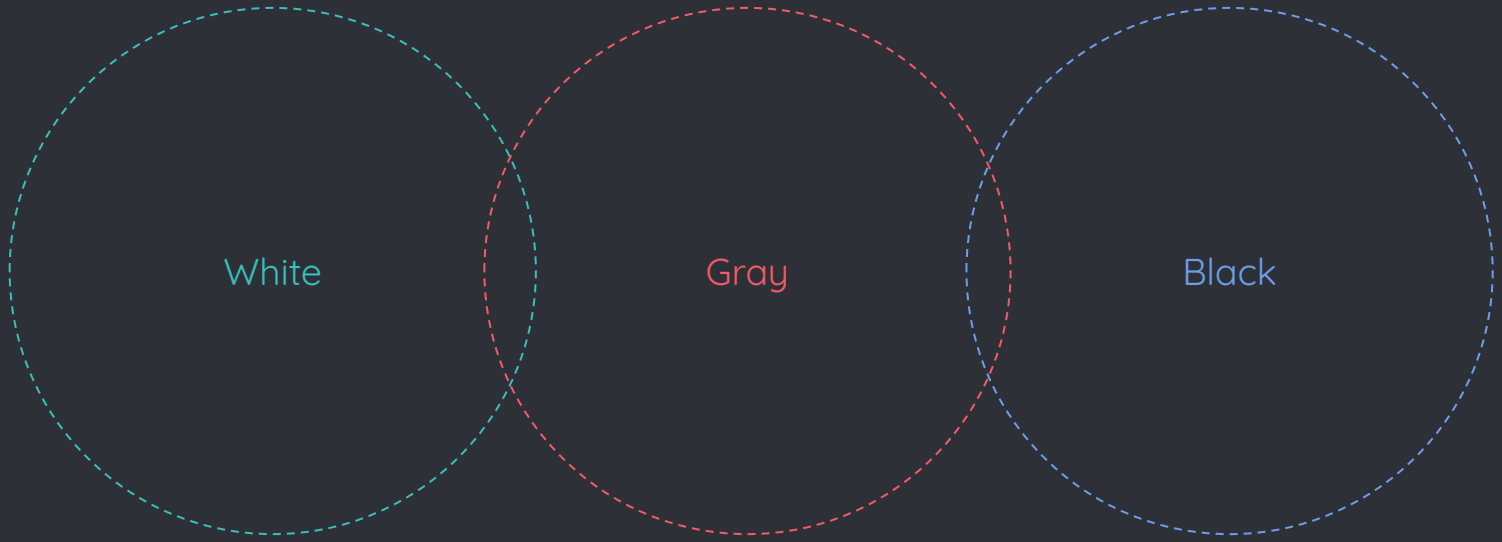
A PICTURE IS WORTH A THOUSAND WORDS

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.

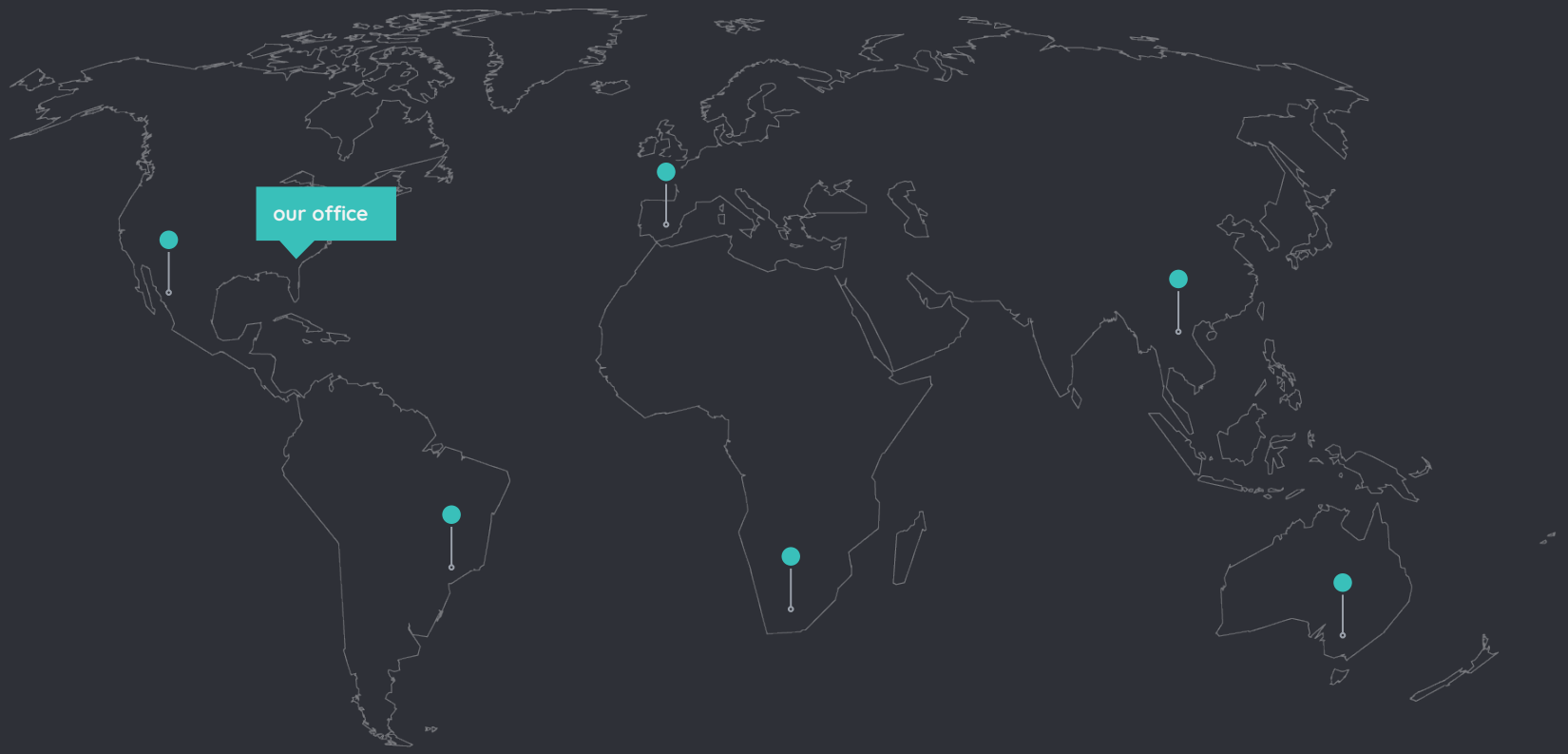
USE CHARTS TO EXPLAIN YOUR IDEAS



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

First

Second

Last

LET'S REVIEW SOME CONCEPTS

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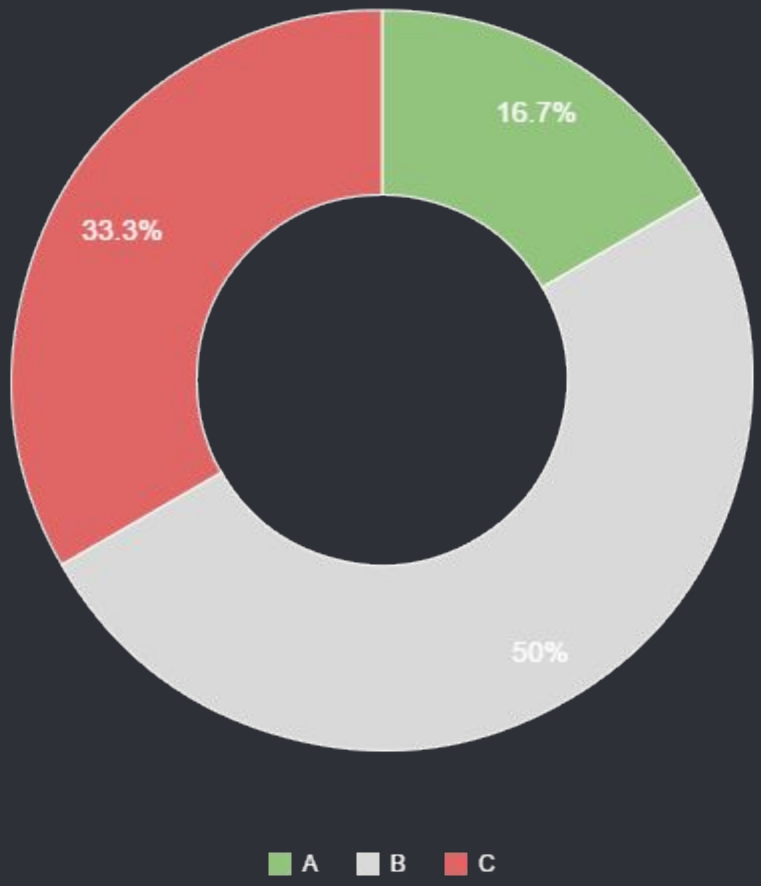

- You can copy&paste graphs from Google Sheets

ANDROID PROJECT

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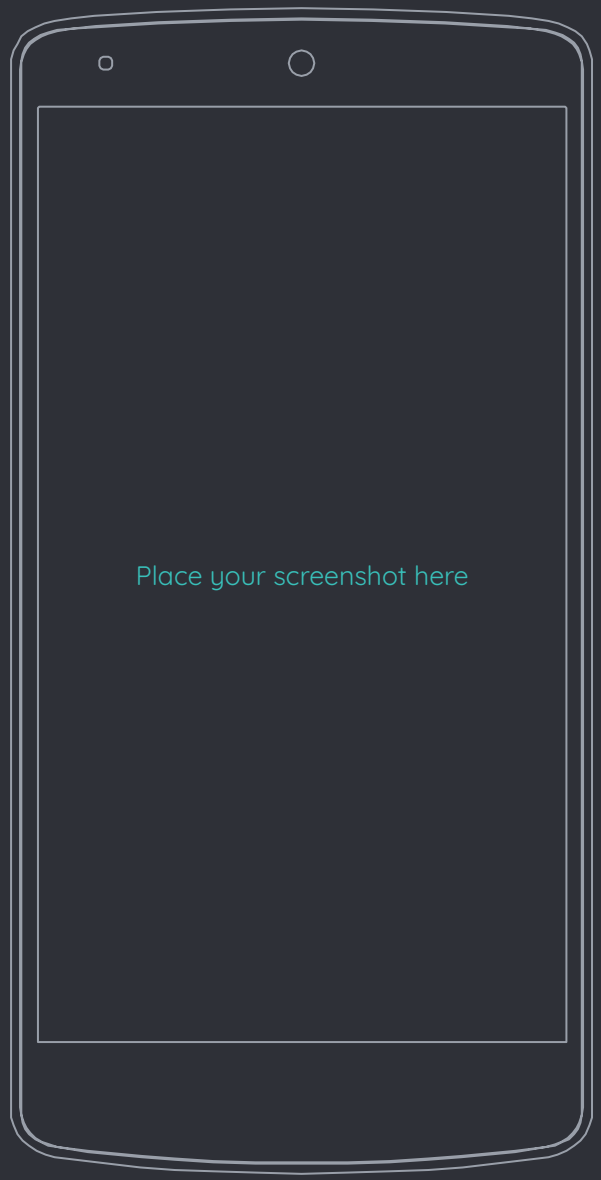

iPHONE PROJECT

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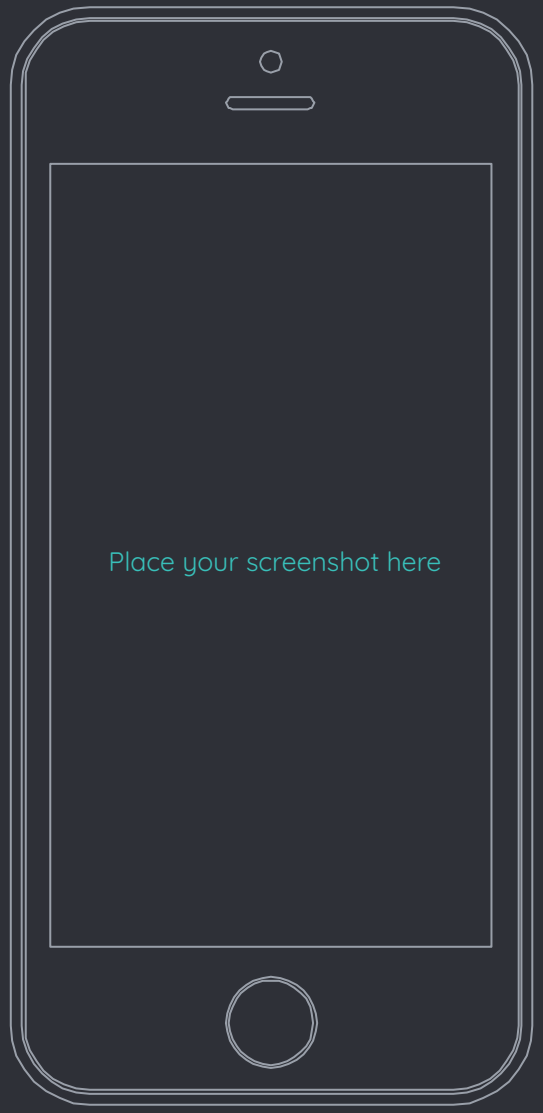

TABLET PROJECT

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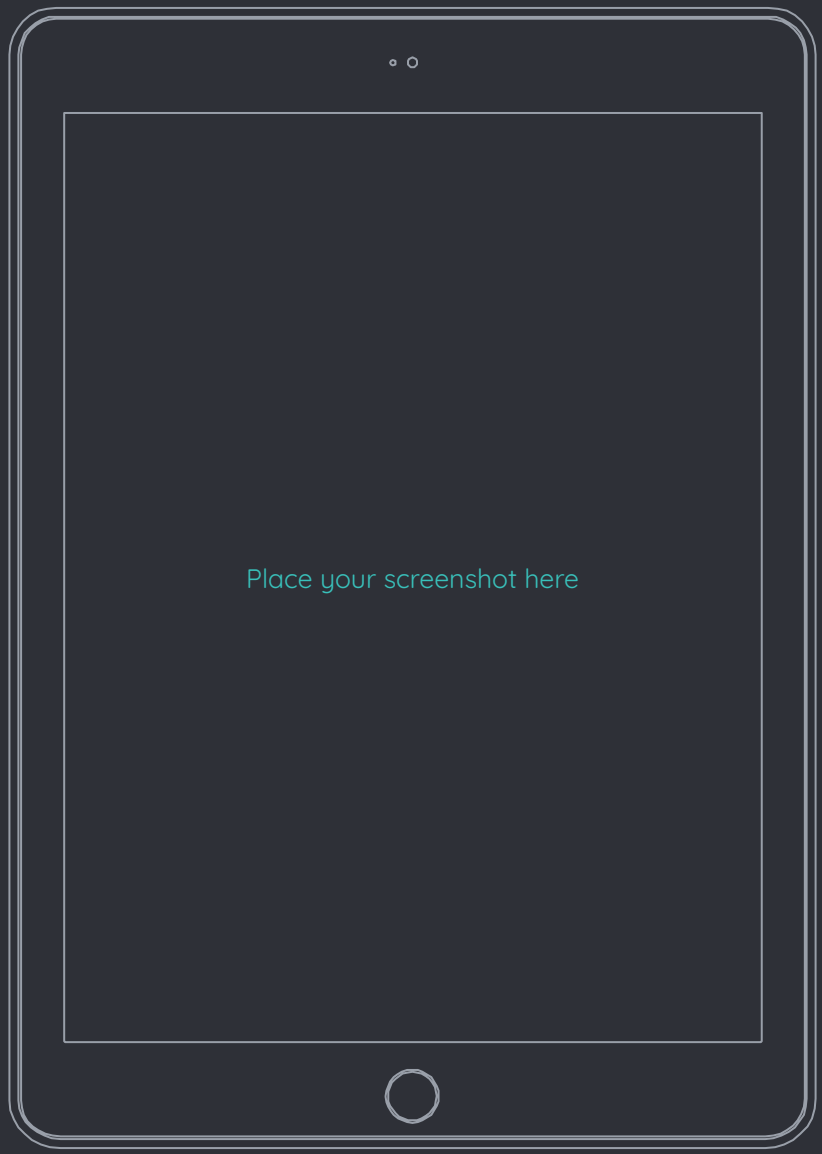

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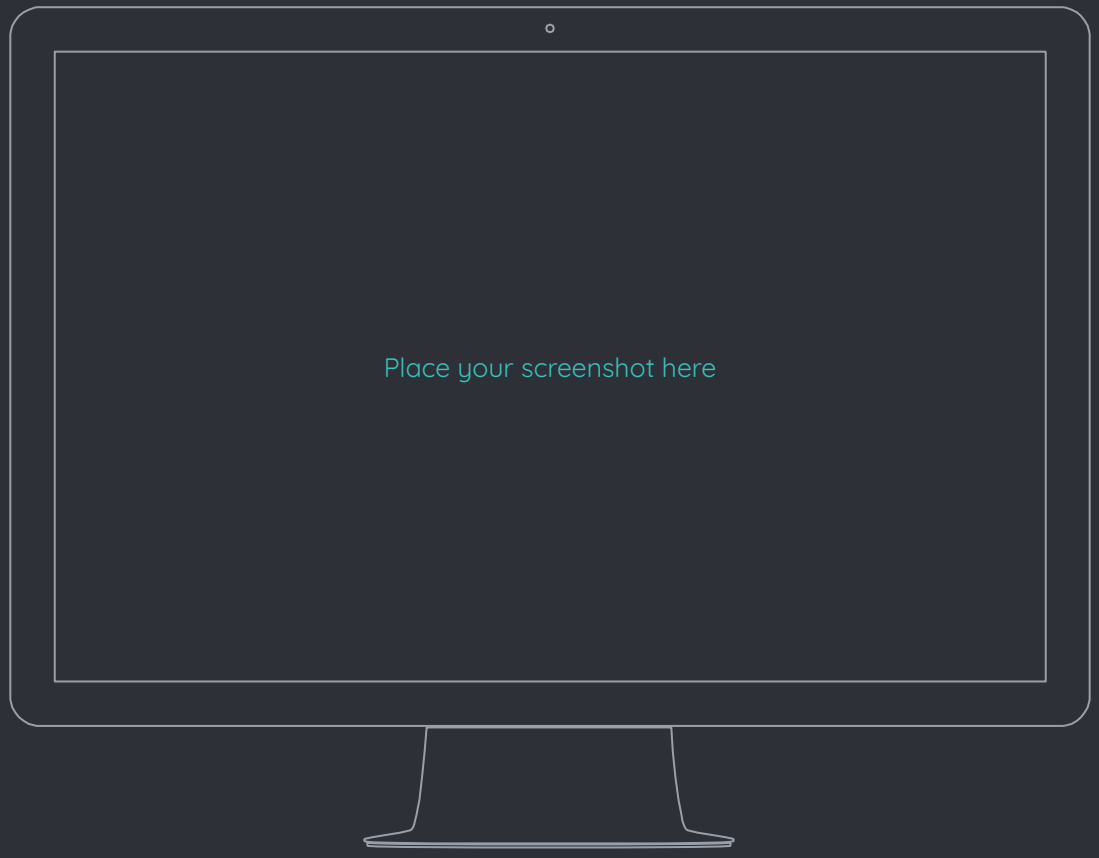


Thanks!

ANY QUESTIONS?

You can find me at

@username

user@mail.me

CREDITS

Special thanks to all the people who made and released these awesome resources for free:

- Presentation template by SlidesCarnival
- Photographs by Unsplash

PRESENTATION DESIGN

This presentations uses the following typographies and colors:

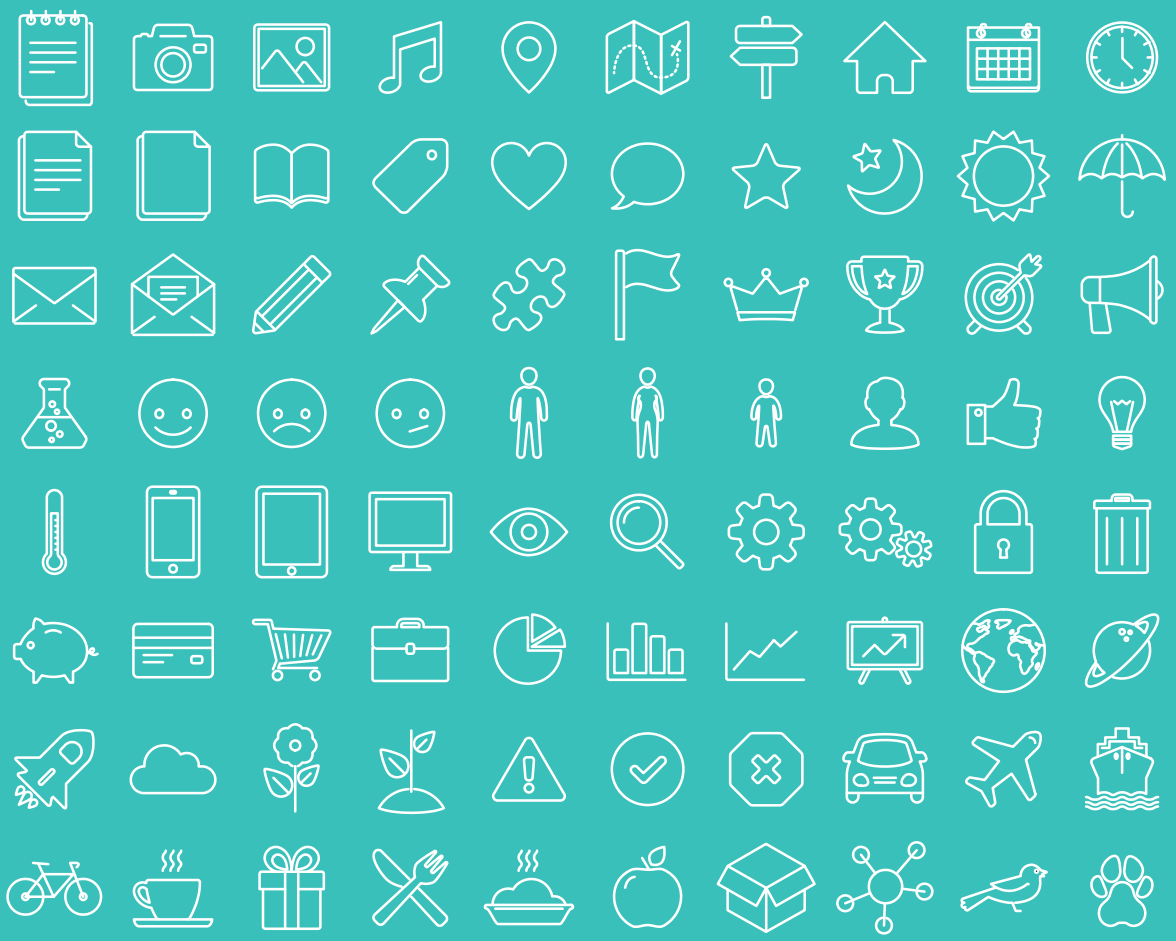
- Titles & body copy: **Quicksand**

You can download the fonts on this page:

https://www.fontsquirrel.com/fonts/quicksand

- Dark gray **#2e3037**
- Aqua **#39c0ba**
- Salmon **#f35b69**
- Blue **#6d9eeb**

You don't need to keep this slide in your presentation. It's only here to serve you as a design guide if you need to create new slides or download the fonts to edit the presentation in PowerPoint®



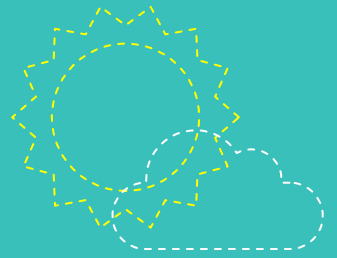
SlidesCarnival icons are editable shapes.

This means that you can:

- Resize them without losing quality.
- Change line color, width and style.

Isn't that nice? :)

Examples:



Now you can use any emoji as an icon!
And of course it resizes without losing quality and you can change the color.

How? Follow Google instructions
https://twitter.com/googledocs/status/730087240156643328

and many more...