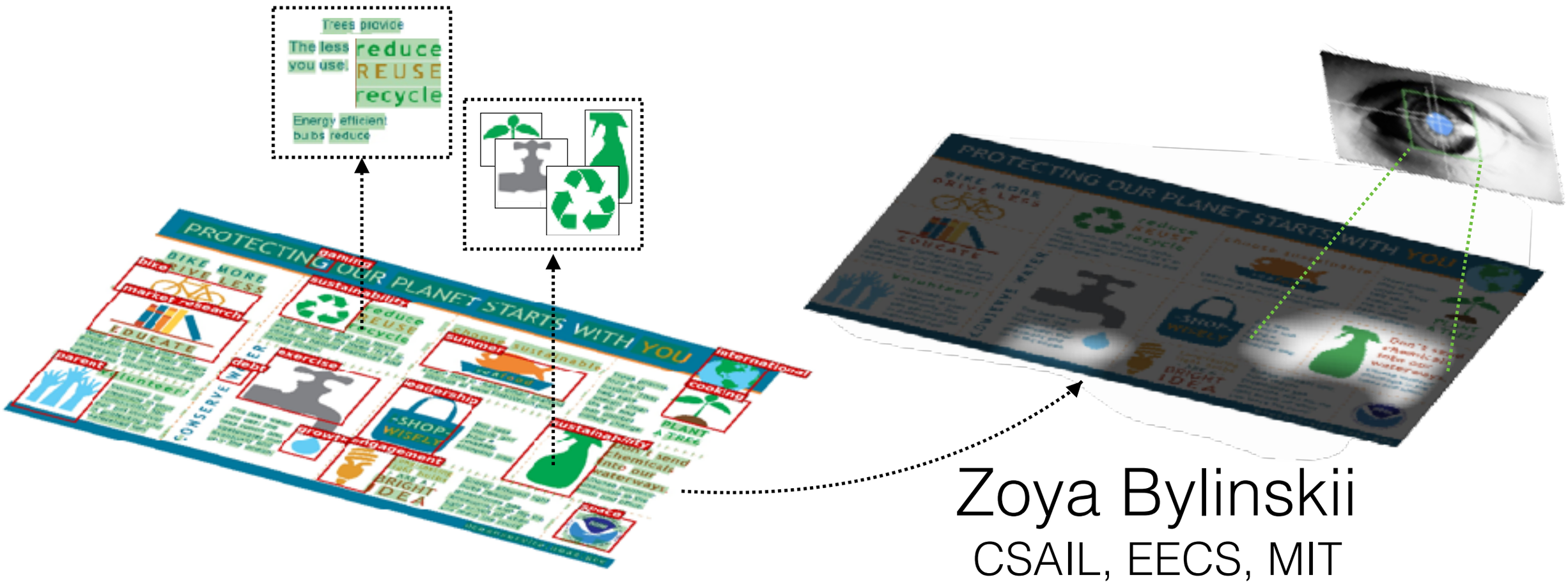
Computational Perception for Multi-Modal

Document Understanding

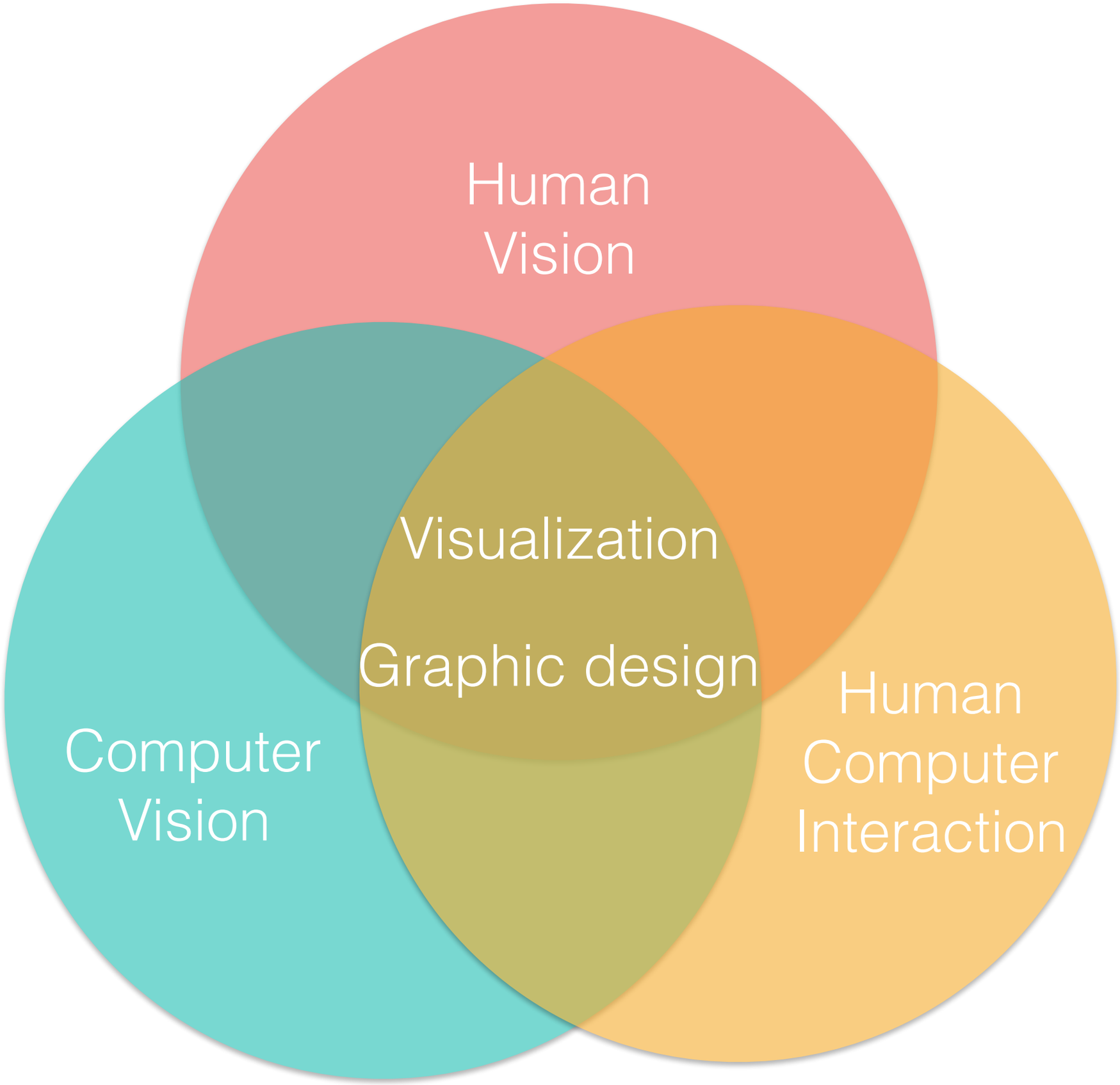


Zoya Bylinskii
CSAIL, EECS, MIT

Thesis Defense Talk

May 1, 2018

Preface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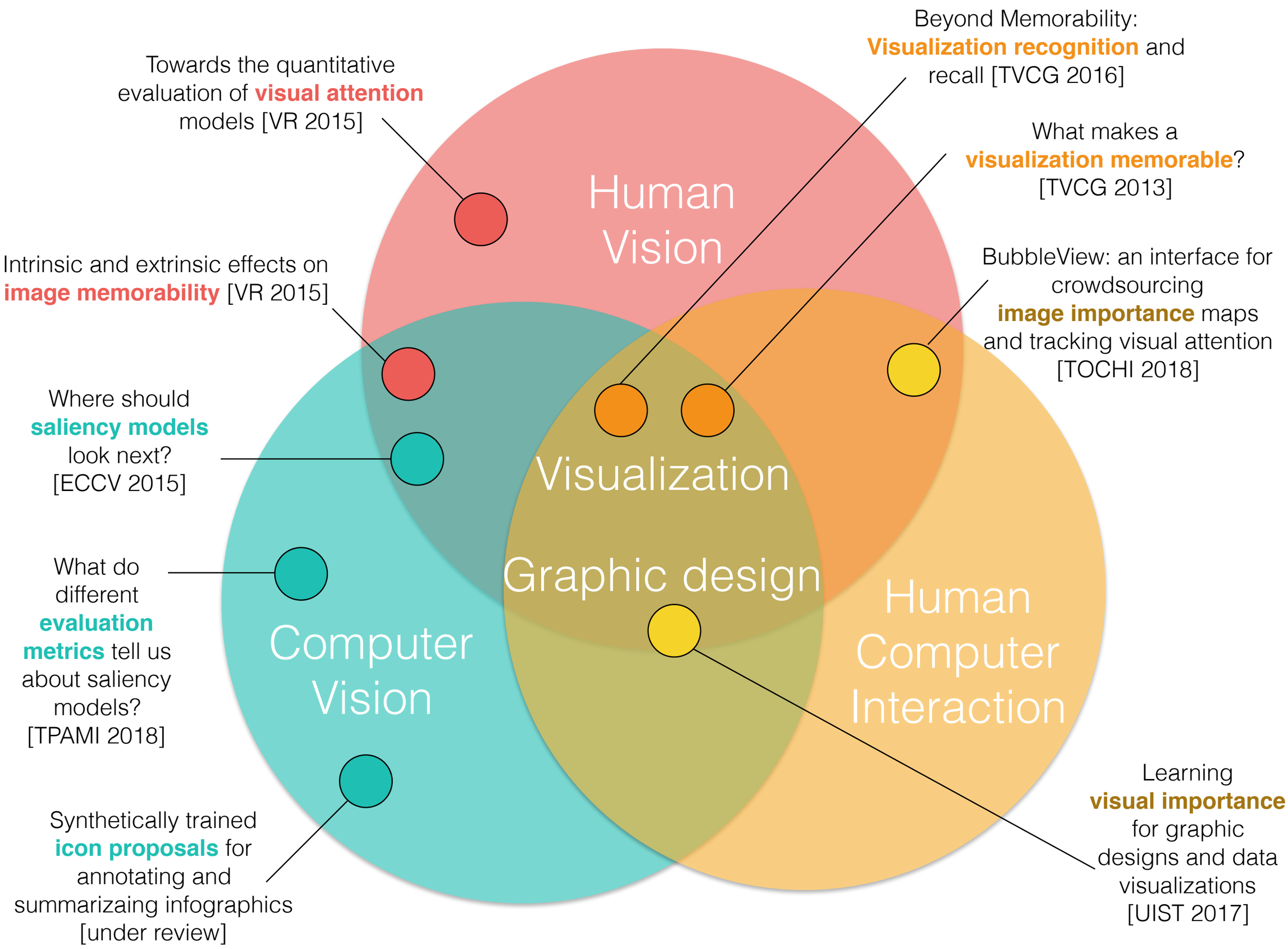
Visualization
Graphic design
Computer
Vision
Human
Computer
Interaction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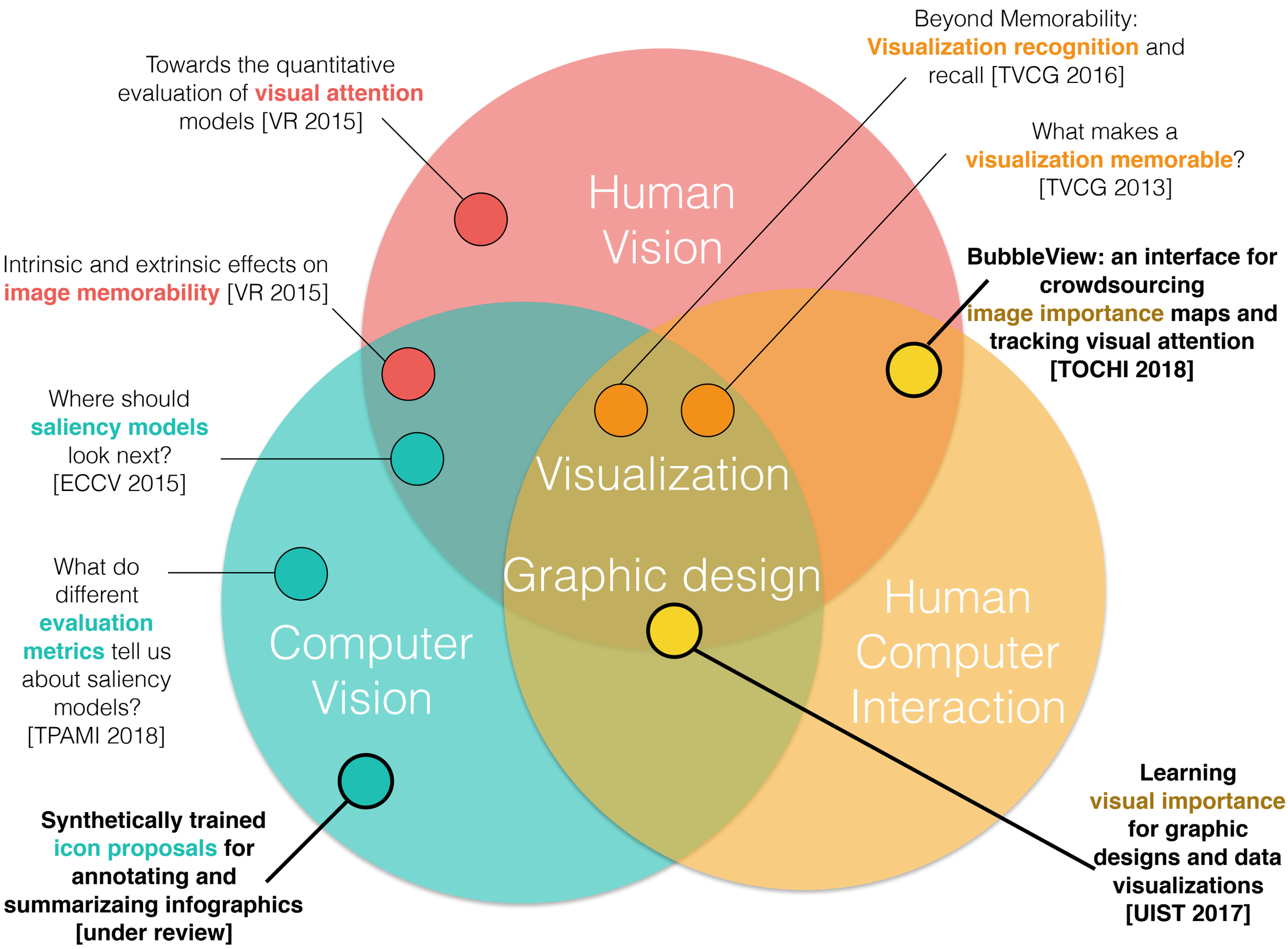
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Introduction

Text

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emission
factory
pollution
energy
eco
temperature
ecosystem
smoke
ozone
greenhouse
ecology
chimney
warming
recycling
renewable
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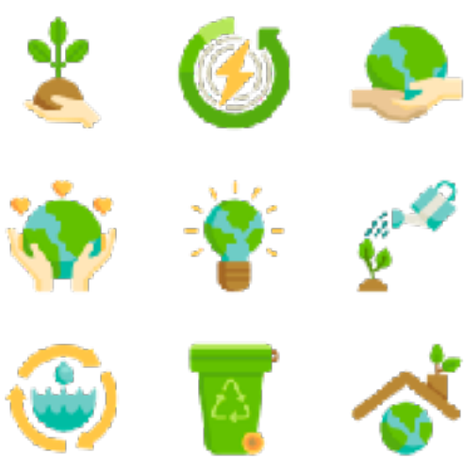

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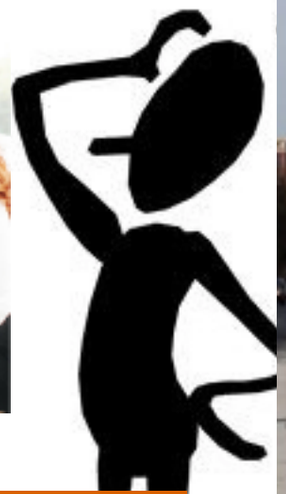

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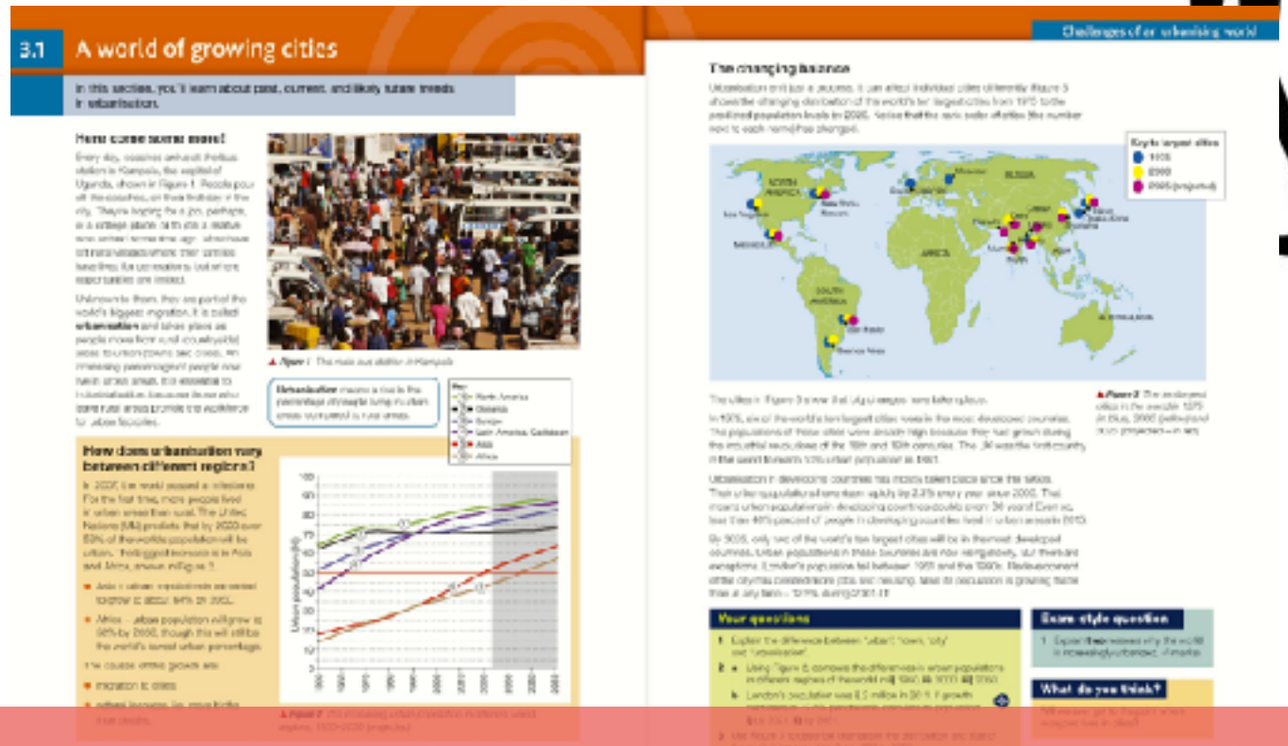

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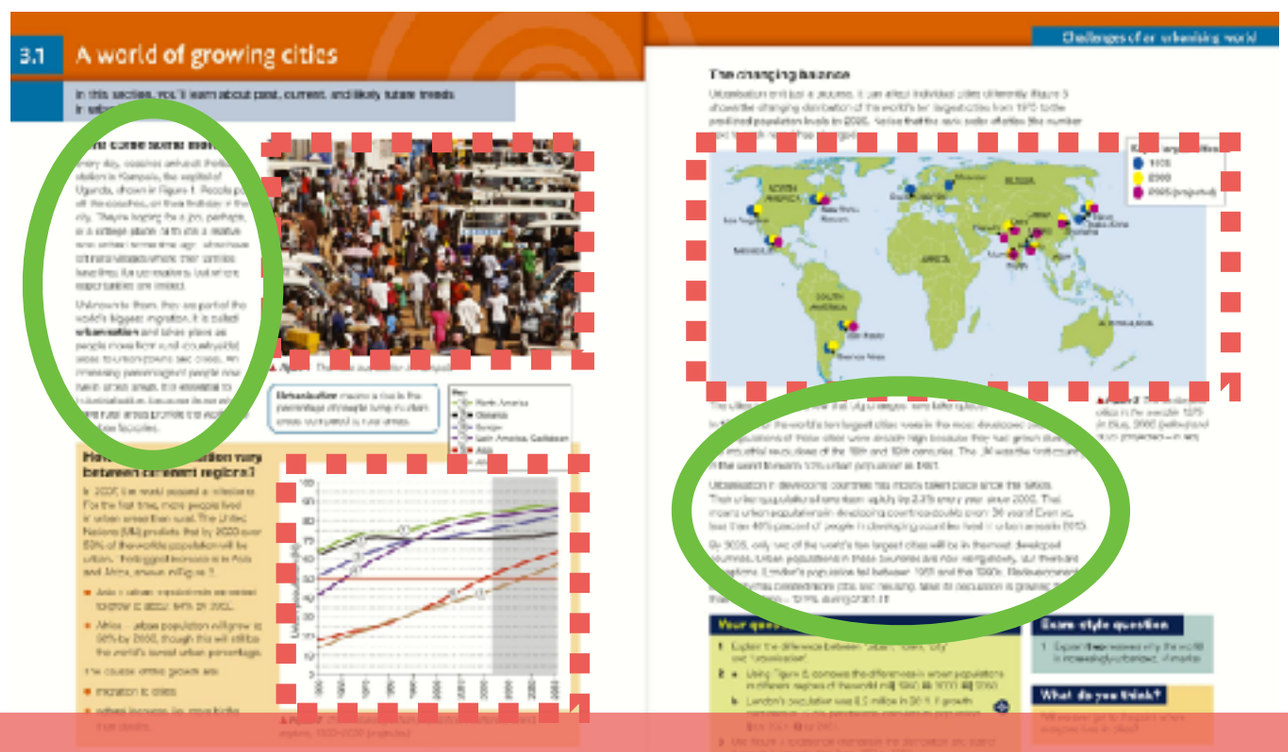

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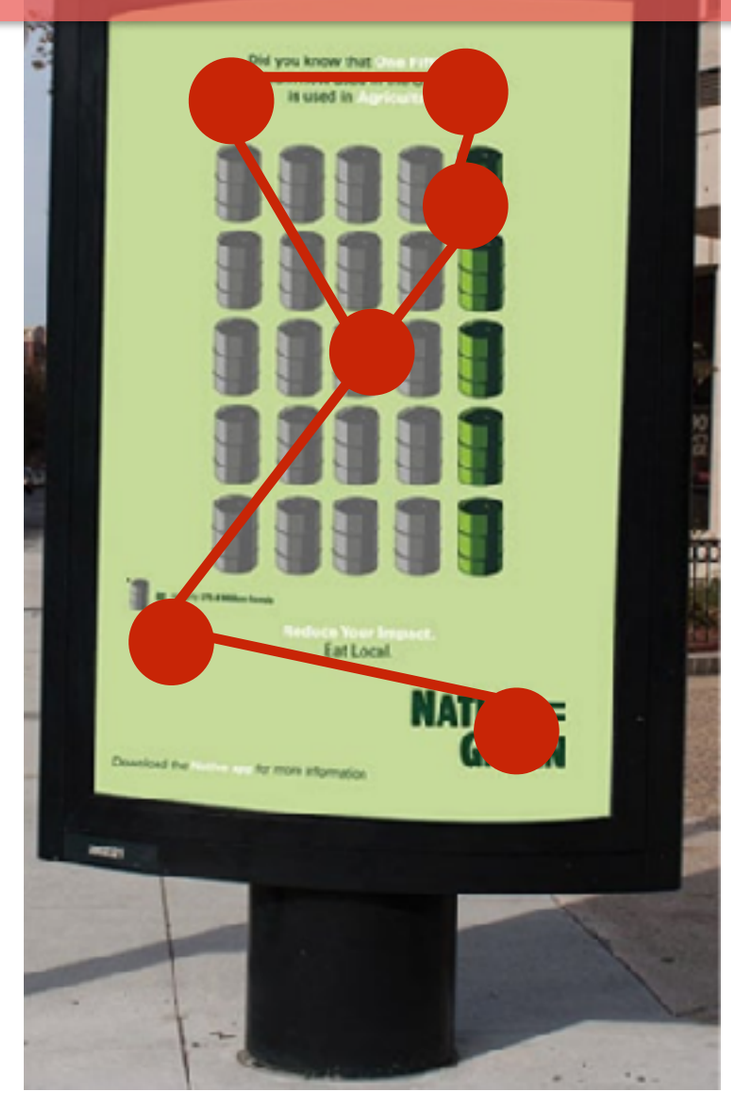

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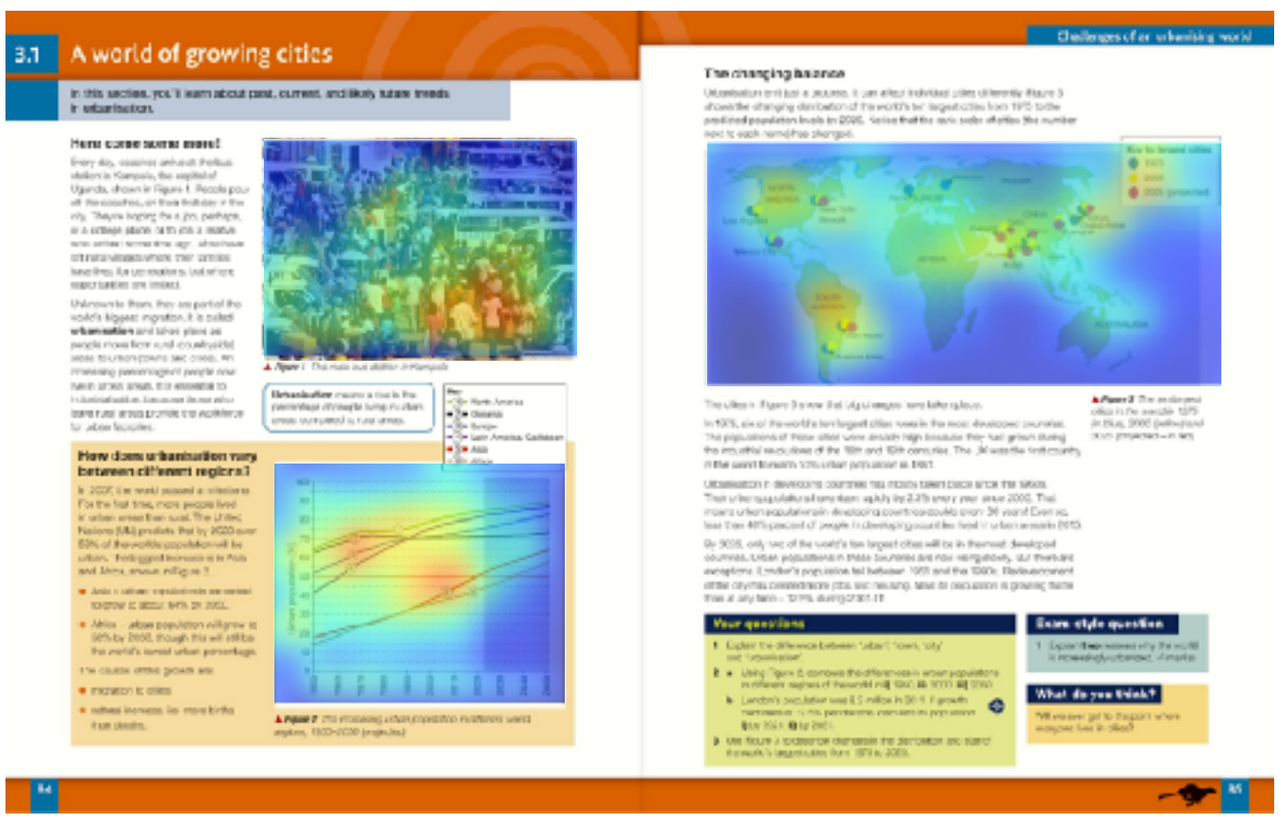
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Challenges of an urbanising world
How does urbanisation vary between different regions?
The changing balance
Your questions
Exam style question
What do you think?

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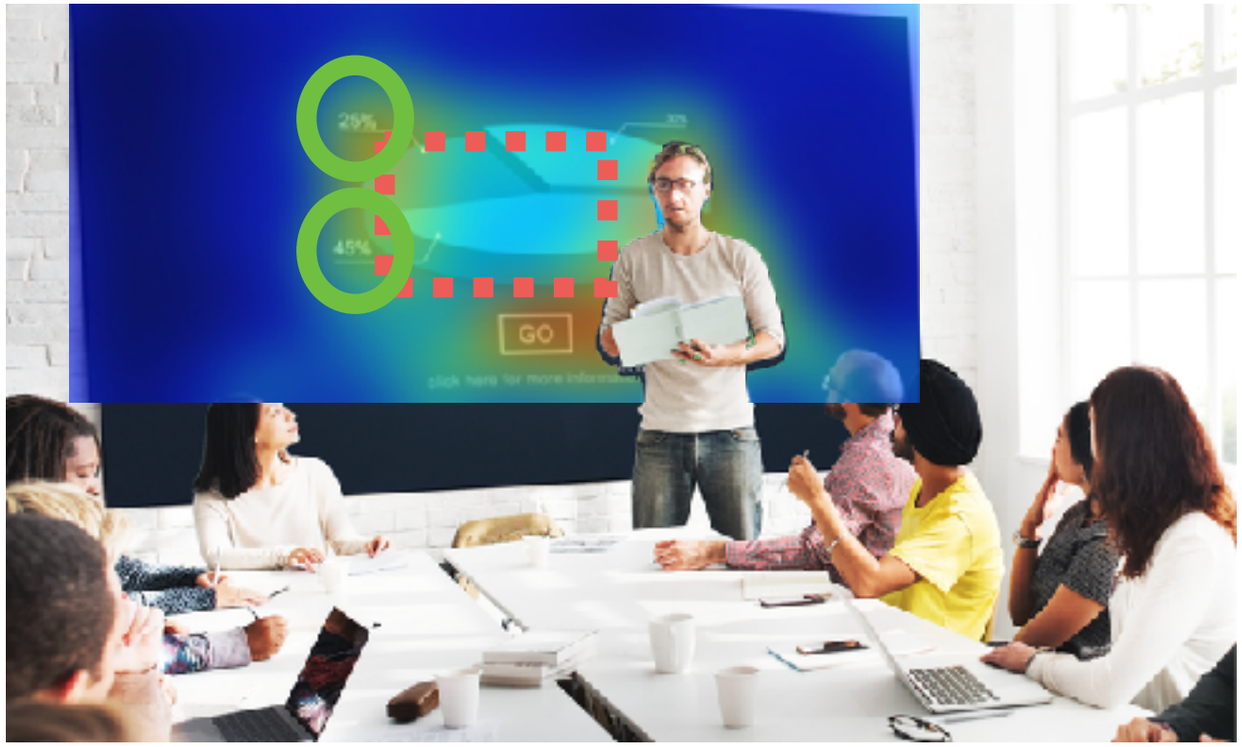
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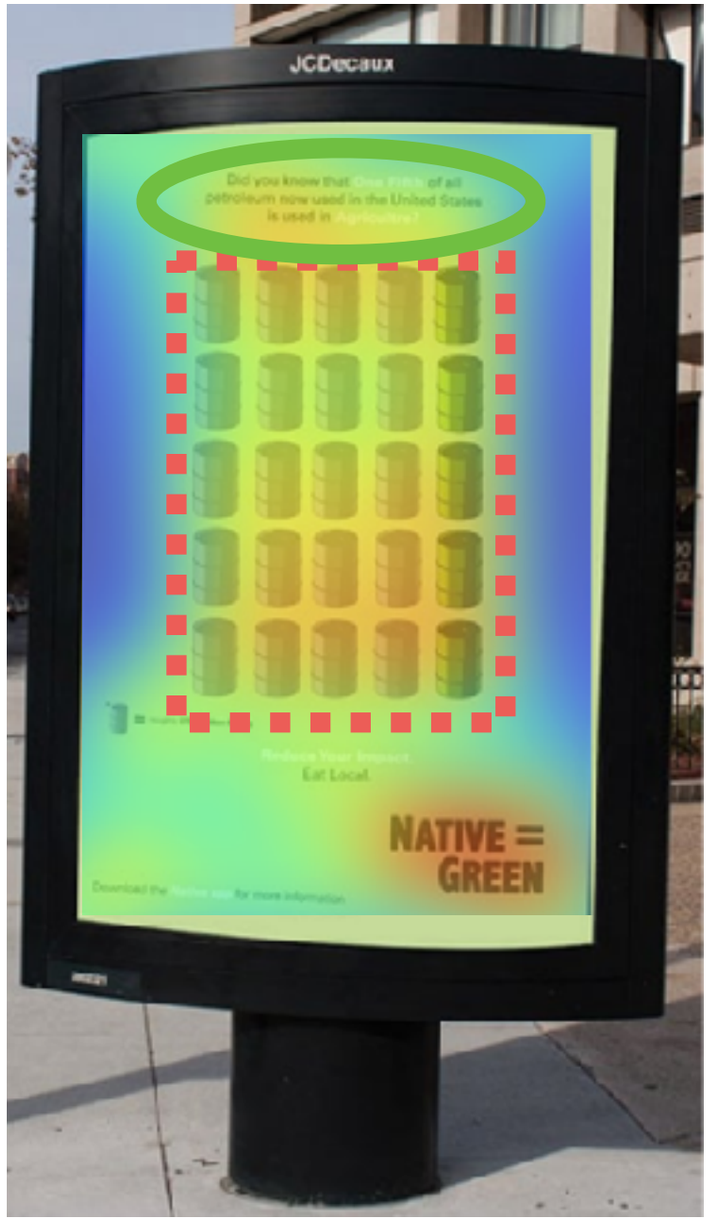
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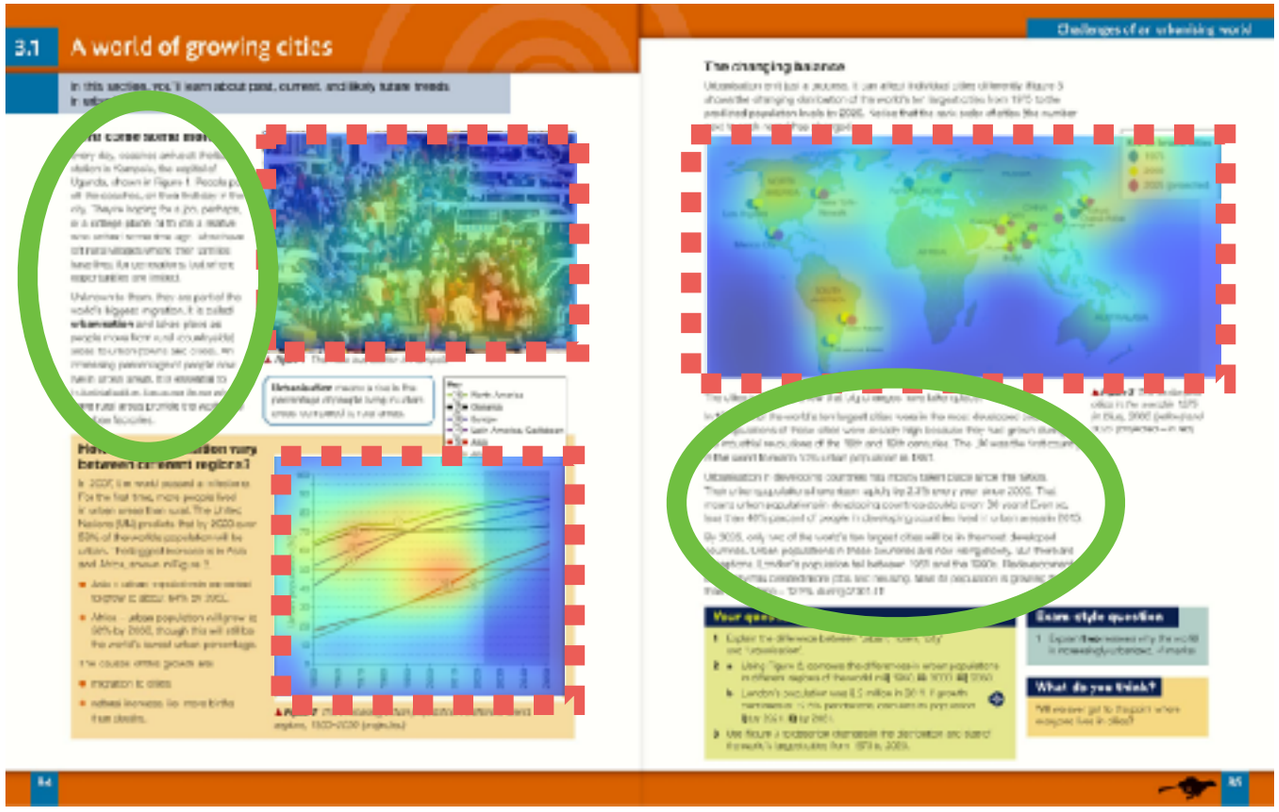
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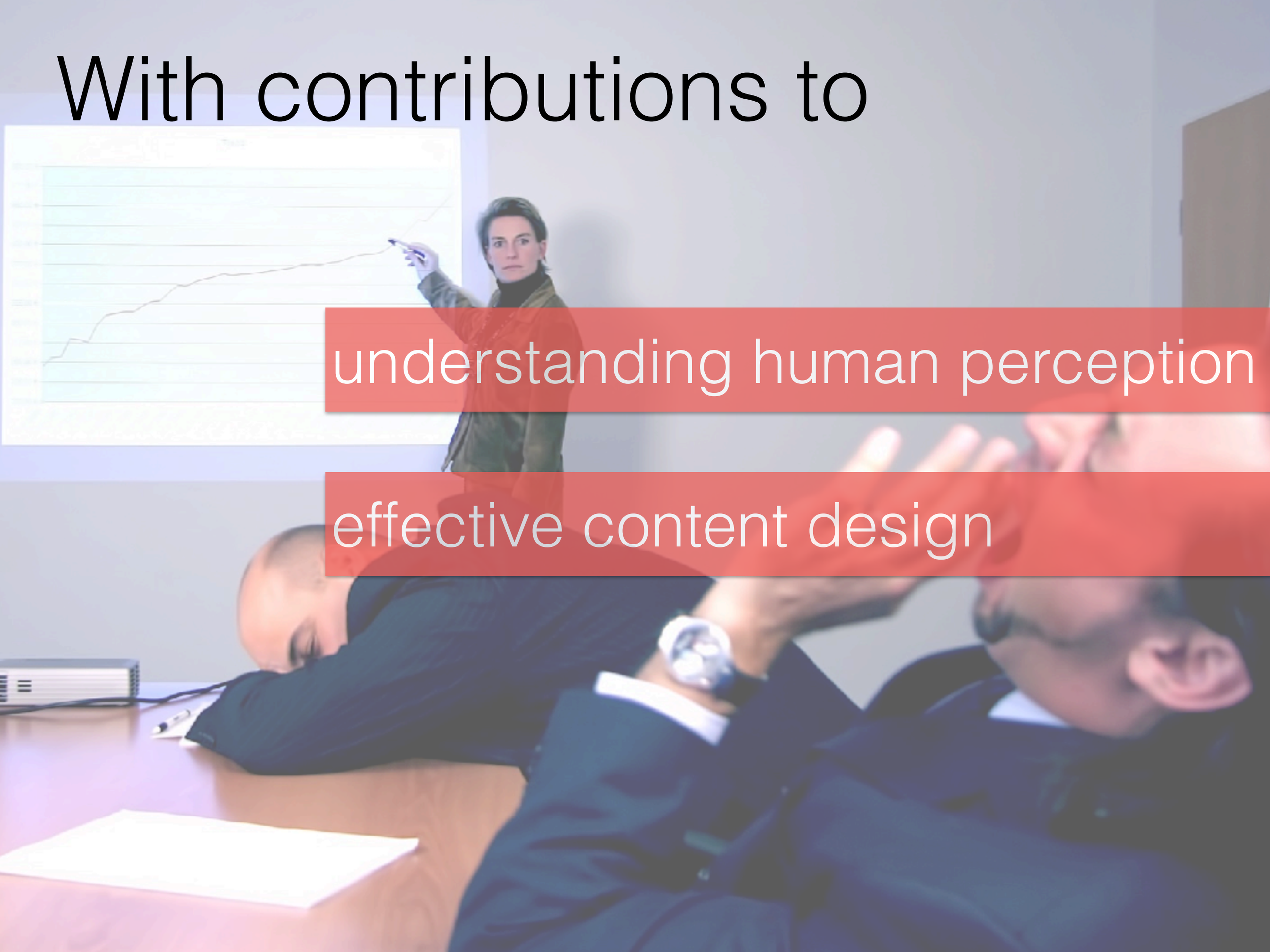

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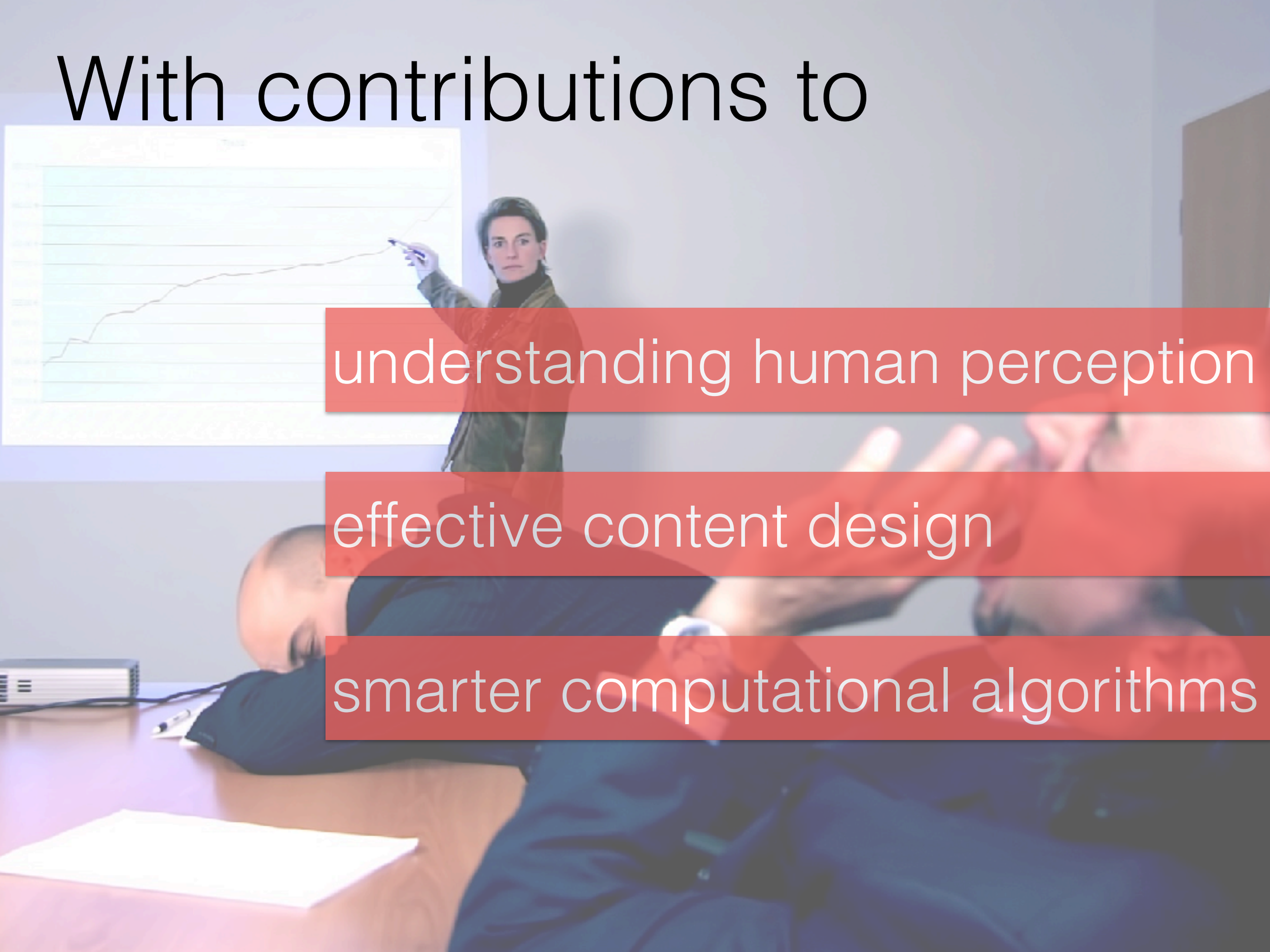

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Foundations & Applications

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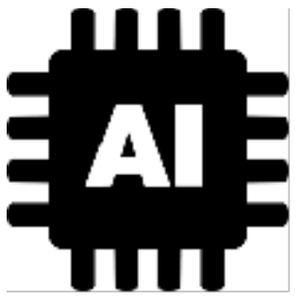

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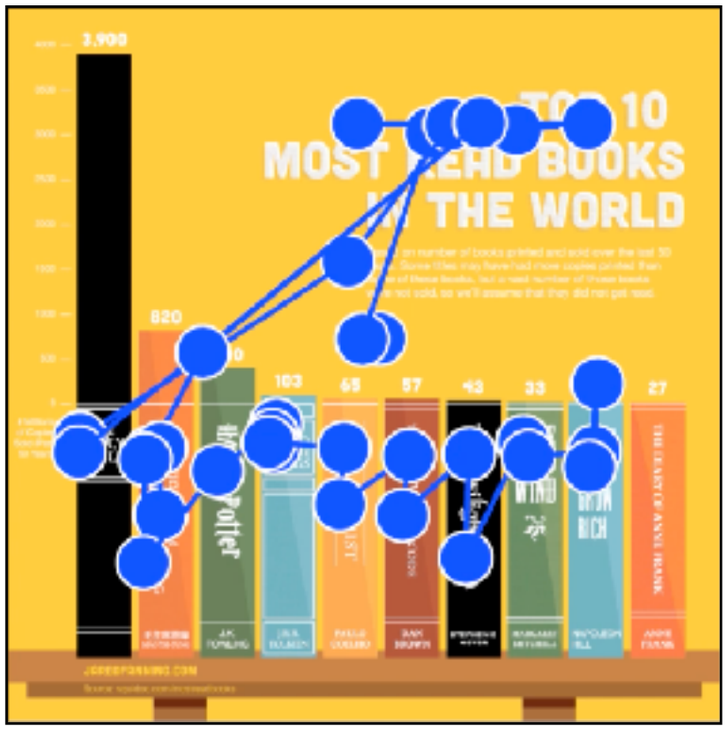

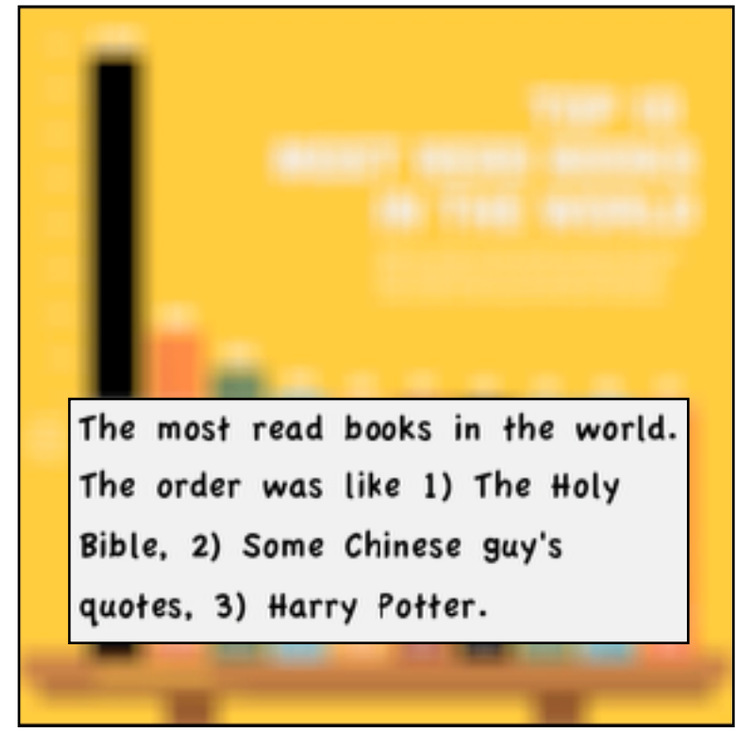

Borkin*, Bylinskii*, et al. [TVCG 2016], Borkin, Vo, Bylinskii, et al. [TVCG 2013]

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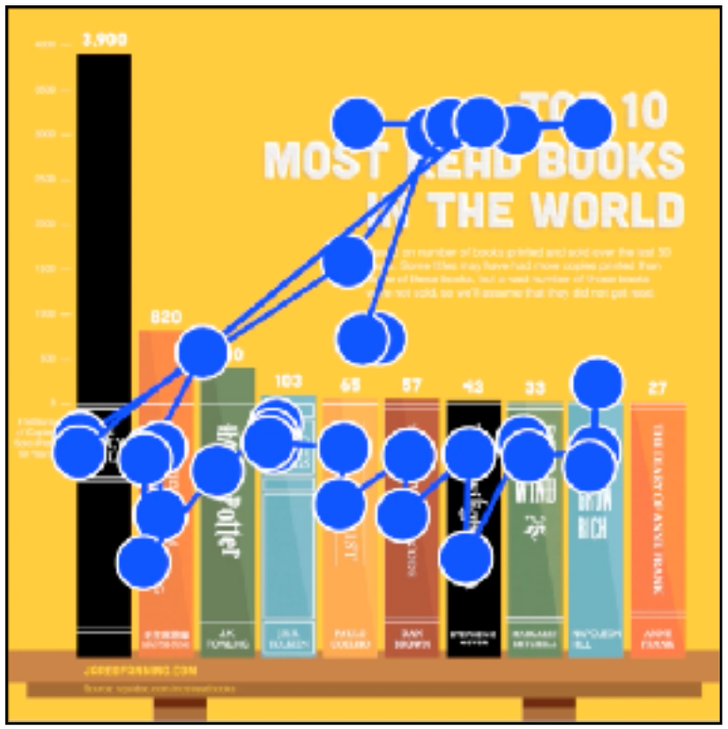

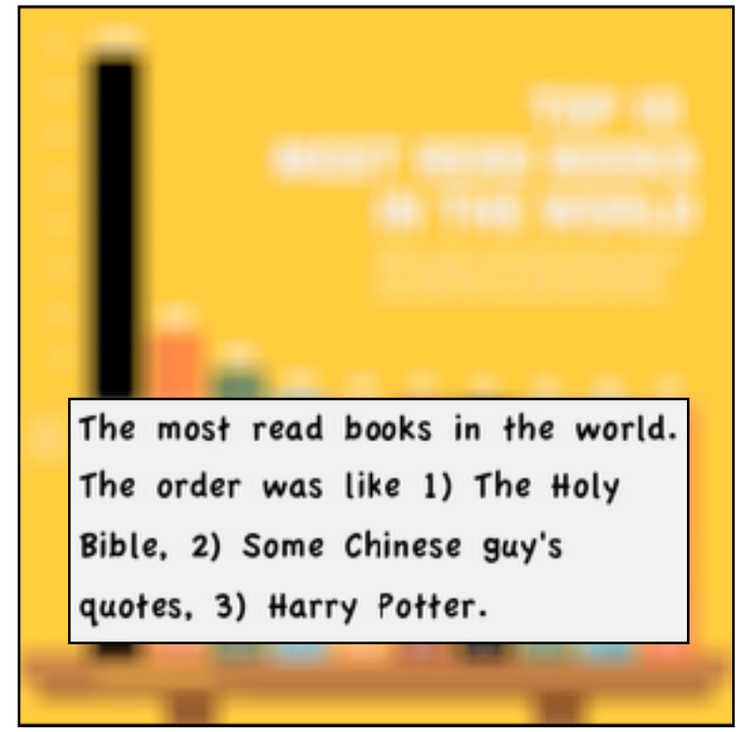

Eye fixations give us important clues about higher level cognitive processes

Borkin*, Bylinskii*, et al. [TVCG 2016], Borkin, Vo, Bylinskii, et al. [TVCG 2013]

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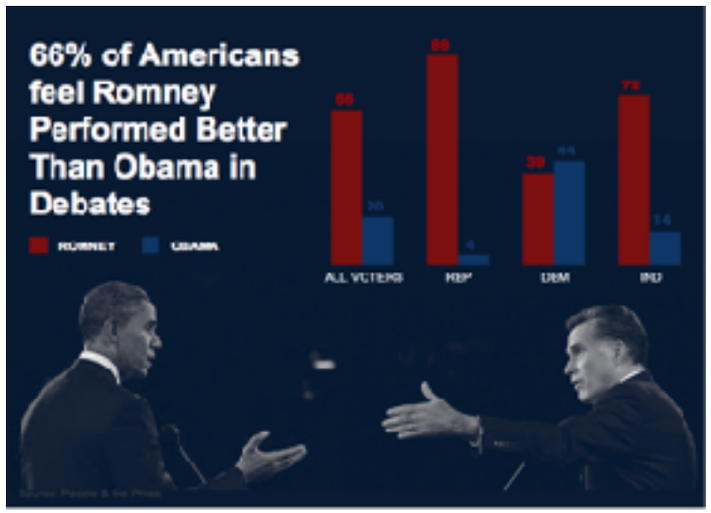

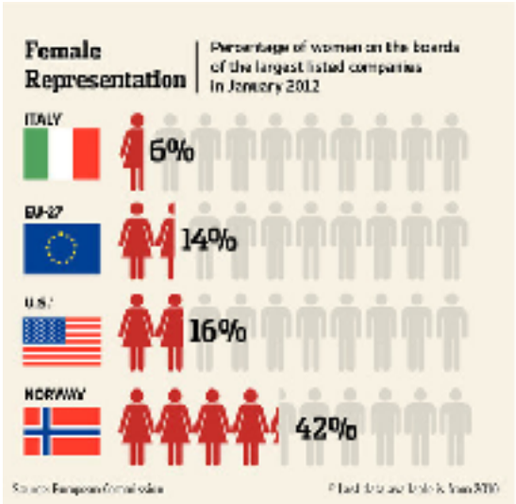

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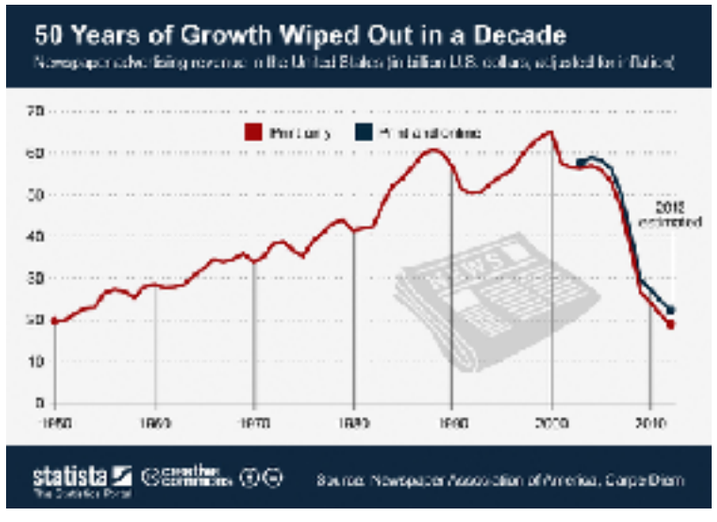

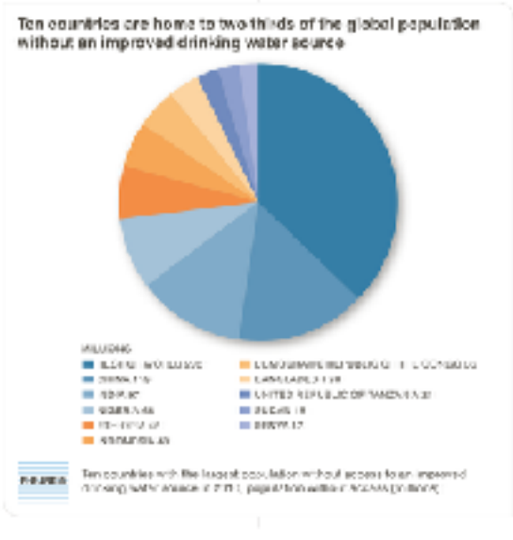

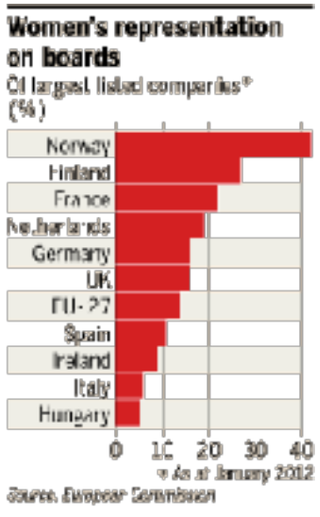

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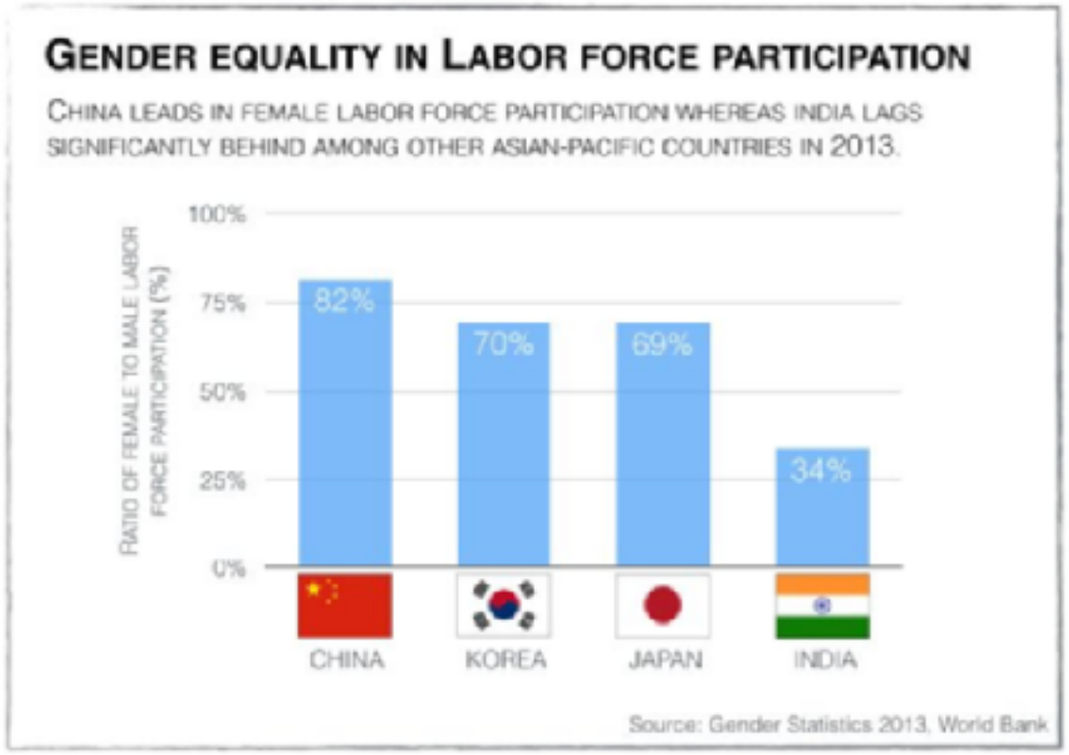

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Borkin*, Bylinskii*, et al. [TVCG 2016]

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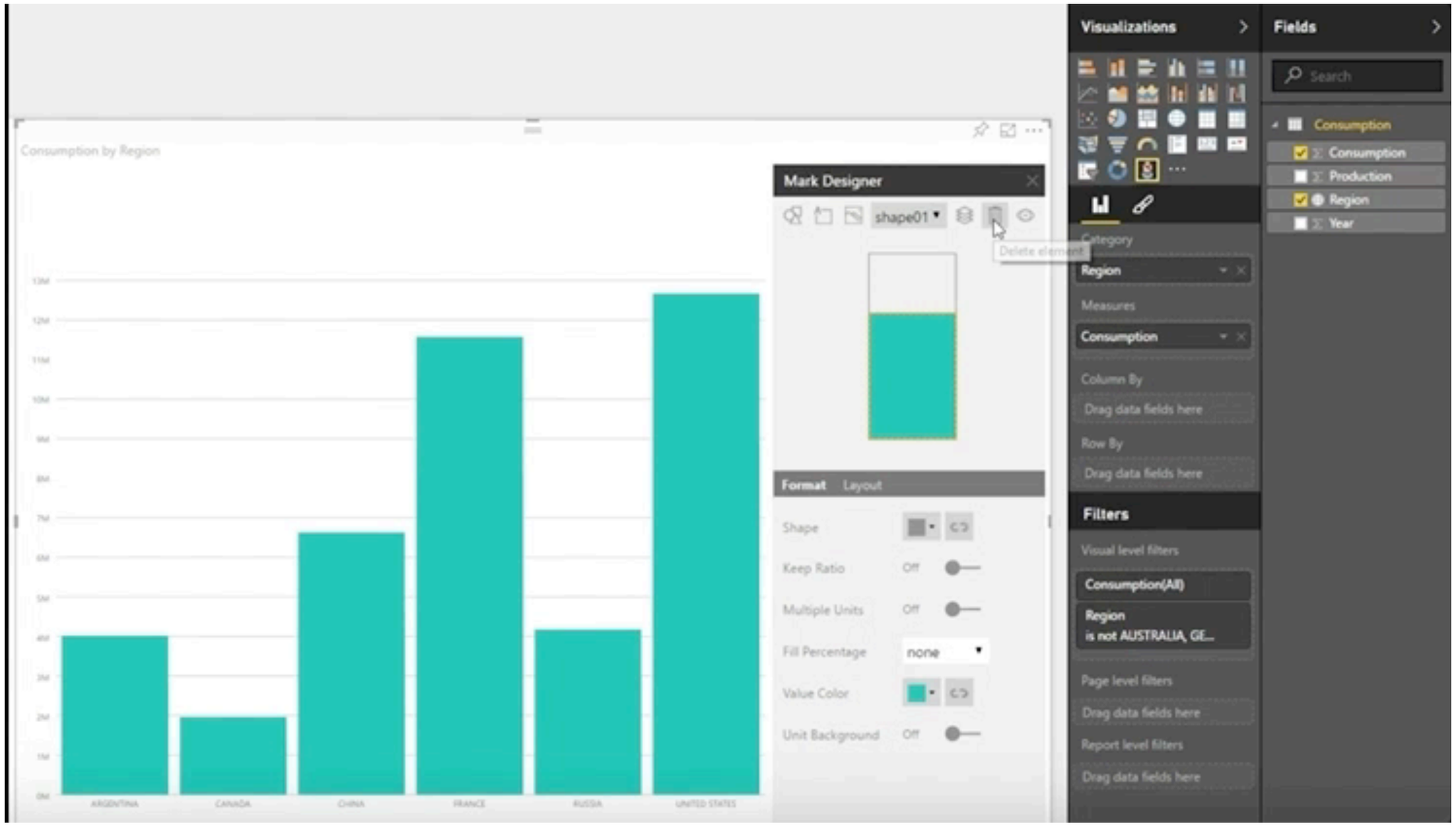

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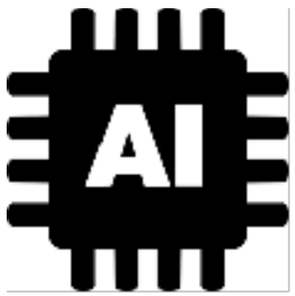

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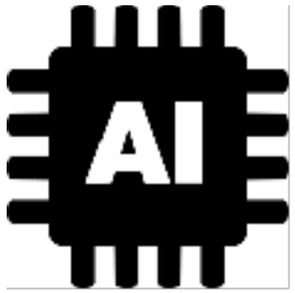

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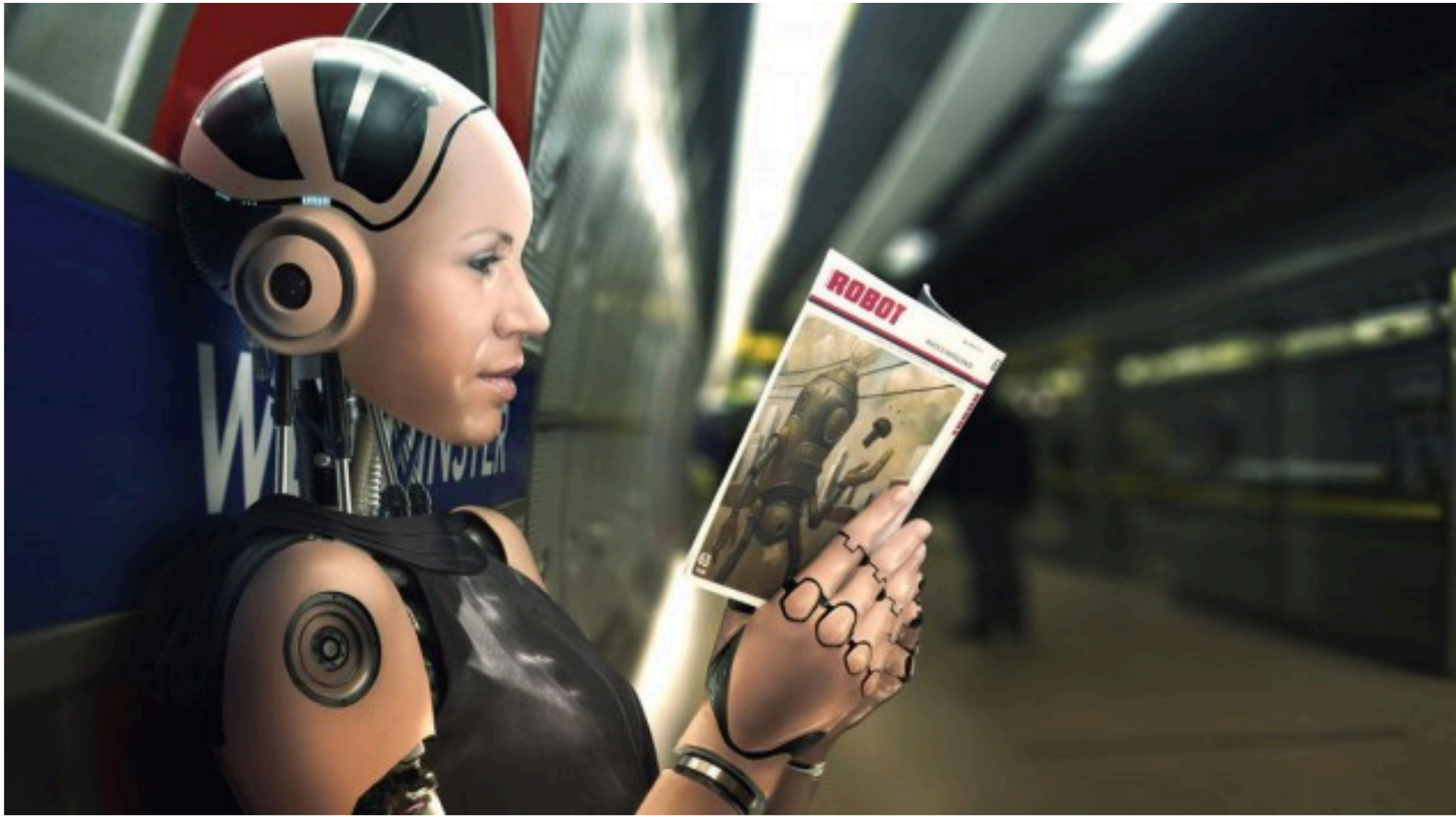

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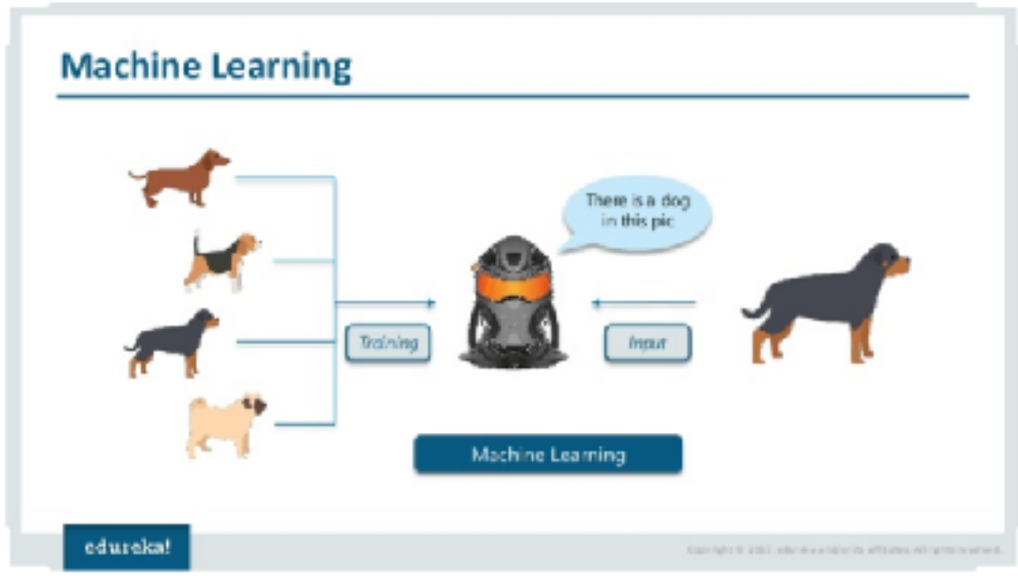

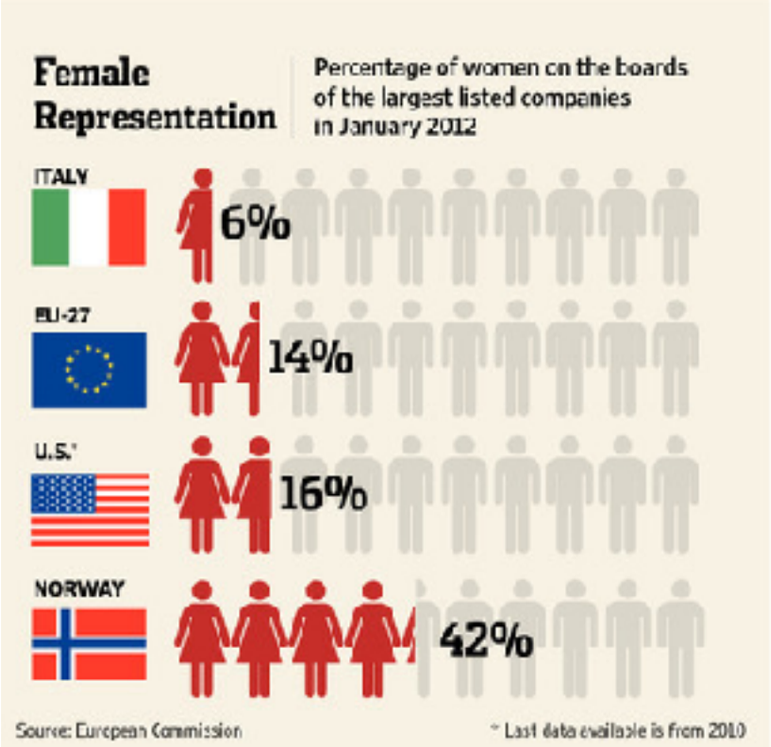

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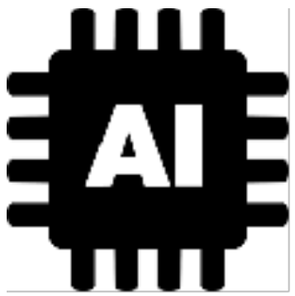

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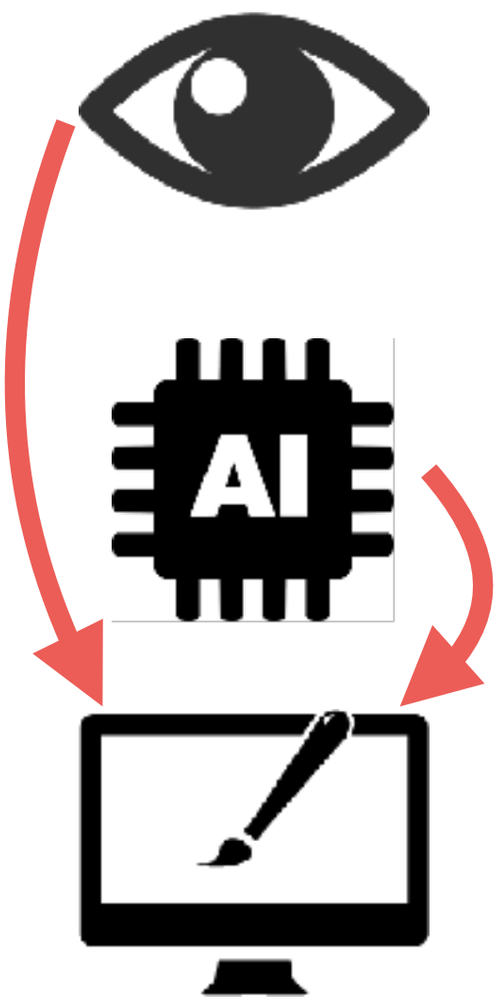

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Food, Sleep, Exercise: Why You Seriously Need All 3 to Be Successful

Healthy people are more productive, creative and mentally sharp.

Rhett Power | July 19, 2017

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Face it. We con't always take care of ourselves as well as we should. It's hard, because life gets in the way—doubly so if we have a busy and productive work life. And when faced with the choice between hard work and convenience, guess which one wins out most of the time?

But whether it's convenient or not, maintaining our health should come first, before our daily to-do's, before our work. Why? Because if we aren't healthy, we can't be successful, either—at home or at work.

Related: **4 Healthy Habits You Already Know but Aren't Doing**

Let's cover the basics—food, sleep, exercise—and why you can't ignore them:

Food

It's lunch time. You've been working since six o'clock in the morning. When those hunger pangs strike, the most appealing option seems to be greasy, ultra-convenient fast food. The last thing you want is a paltry little meal like a salad. But what are those excessive calories found in burgers and fries actually doing to your post-lunch productivity?

What you eat affects your productivity in different ways, so eat smart.

Writing for the *Harvard Business Review*, Ron Friedman lays out the facts about how different foods affect work performance. He cites a study where participants reported "food consumption, mood and behaviors over a period of 13 days." The participants who ate less high-fat meals and more fruits and vegetables were "happier, more engaged and more creative" than those who opted for high-fat, high-calorie lunches.

We tend to think simplistically about food. Those of us who face a daily barrage of emails, reports and mounds of work like to think of it as "fuel." That analogy is a little misleading, however. As Friedman points out, you can expect a certain level of consistency with fuel. Food, on the other hand, is less predictable. What you eat affects your productivity in different ways, so eat smart.

Related: **SUCCESS Recipes: Kale Caesar Salad**

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EXCLUSIVE nutrition

Eat, drink and sleep more

If the season of shorts, or if you are a teenager: the season of very short shorts, is filling you with dread, then there are a few steps you can take to ensure a better summer body this year. Nottingham-based nutritionist, EVA HUMPHRIES, shares her top tips for effortless weight loss

WHAT if, you could lose a few pounds *and* feel better and the effort-to-effect ratio was minimal? As in minimum effort, maximum results?

EXCLUSIVE magazine's new food writer Eva Humphries has an action plan and trust us when we say it is ridiculously easy to follow...

Drink more water

Drinking more water is not a new recommendation but it is an important one and for good reason too. Aside from its beneficial effect on your skin, kidneys and cardiovascular system, it may also reduce rates of long term weight gain.

Research indicates that people put on over 2lbs every four years, except this trend is not the same if you drink water.

Just adding an extra cup of water to your daily intake can have beneficial effects on your weight. 6-8 glasses of water a day should be sufficient but individual differences do exist. If you exercise, have an active job or eat a high protein diet then you may need more.

Protein for breakfast

Eating breakfast has long been associated with a healthier body weight but it turns out what you eat is just as important.

According to a recent study, consuming protein for breakfast regulates your appetite for the rest of the day, meaning you are less likely to give in to that post lunch slice of cake.

A further study also found that eating a high protein breakfast is protective against weight gain, whereas a breakfast without protein is not.

Time to deploy those soldiers and crack some eggs.

Eat more, not less

This recommendation may come as a surprise, however consider this: the more you eat, the higher your metabolism is.

By now you must be thinking eating more is also how you get fat and you wouldn't be wrong. Yes, there is a caveat in making eating more work for you, which is that you have to eat better.

A large population study carried out in the US and UK found those who ate six or more meals a day had a lower body mass index in comparison to those that ate four or less meals.

The slim-and-toned brigade eat fewer calories and their meals contained more nutrients.

Increasing the amount of nutrients should be the main aim of any weight-loss plan.

Since most of the vitamins and minerals we need come from plants, our focus needs to shift to consuming a greater proportion of our calories from vegetables.

Practically adding more veggies may look like this: a handful of spinach and a grilled tomato with your poached egg on toast at breakfast, a side salad with your lunchtime sandwich, some peas and green beans alongside your normal dinner.

Eat more but do eat better.

Sleep longer

In case you need an excuse for that lie, there is scientific proof that those who sleep longer tend to be slimmer.

The reasons are twofold:

1. As humans, we are programmed to seek out food while awake, thus a longer time spent awake adds up to more food consumed.

2. Following sleep deprivation, our ability to resist food reduces and we naturally go in pursuit of the nearest carbohydrate source.

In case you hit that snooze button too many times in the morning, just remember you probably still have a job to go to.

Getting to bed earlier is the best policy.

Eva has devised two beautiful recipes for Exclusive – Watermelon Salad and Blueberry Nice Cream.

Watermelon salad

This refreshing salad is full of the right kind of nutrients. Eat it as a side salad alongside a summer BBQ or sprinkle some feta cheese on top to create a fulfilling lunch.

Ingredients (serves two)

10 mint leaves, torn
2 slices of watermelon, chopped into bite-sized chunks
4 handfuls of mixed salad leaves
1/2 cucumber, turn into ribbons with a peeler
Juice of 1 lime
2 tablespoons of olive oil

Method:

Put the salad leaves, mint and cucumber into a large bowl. Drizzle over the olive oil and squeeze over the lime juice. Stir to coat well. Scatter over the melon and serve immediately.

Blueberry nice cream

When ice cream is out of reach, make this nourishing, three-ingredient "nice" cream instead. It contains no sugar or dairy yet delivers maximum taste.

Ingredients (serves four)

1 cup of cashews, soaked overnight in water and drained
2 cups of frozen blueberries
6 drops of vanilla

Method:

Put all of the ingredients in a high speed blender and blend until smooth. Scoop into ice cream bowls and enjoy.

About Eva Humphries

Eva Humphries is a Nottingham-based nutritionist and founder of the health and wellness website wholeloedwarrior.co.uk. She holds regular nutrition talks on topics including weight loss, improving energy and boosting the immune system.

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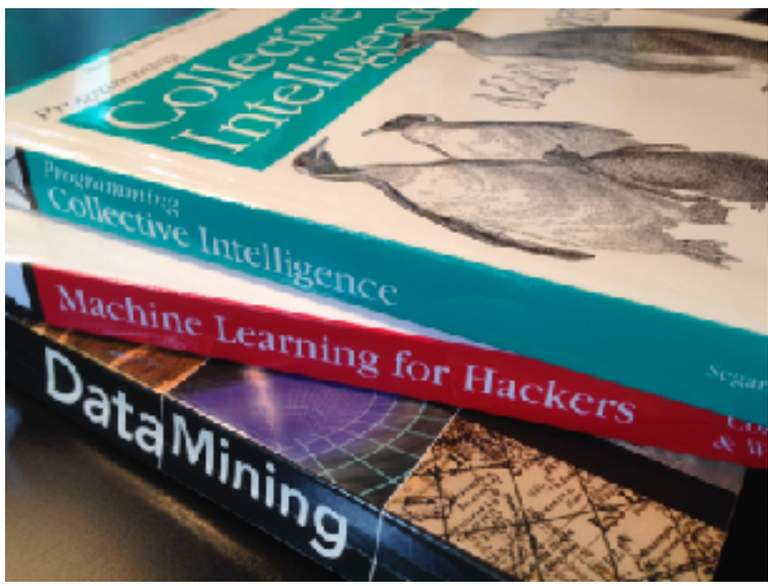

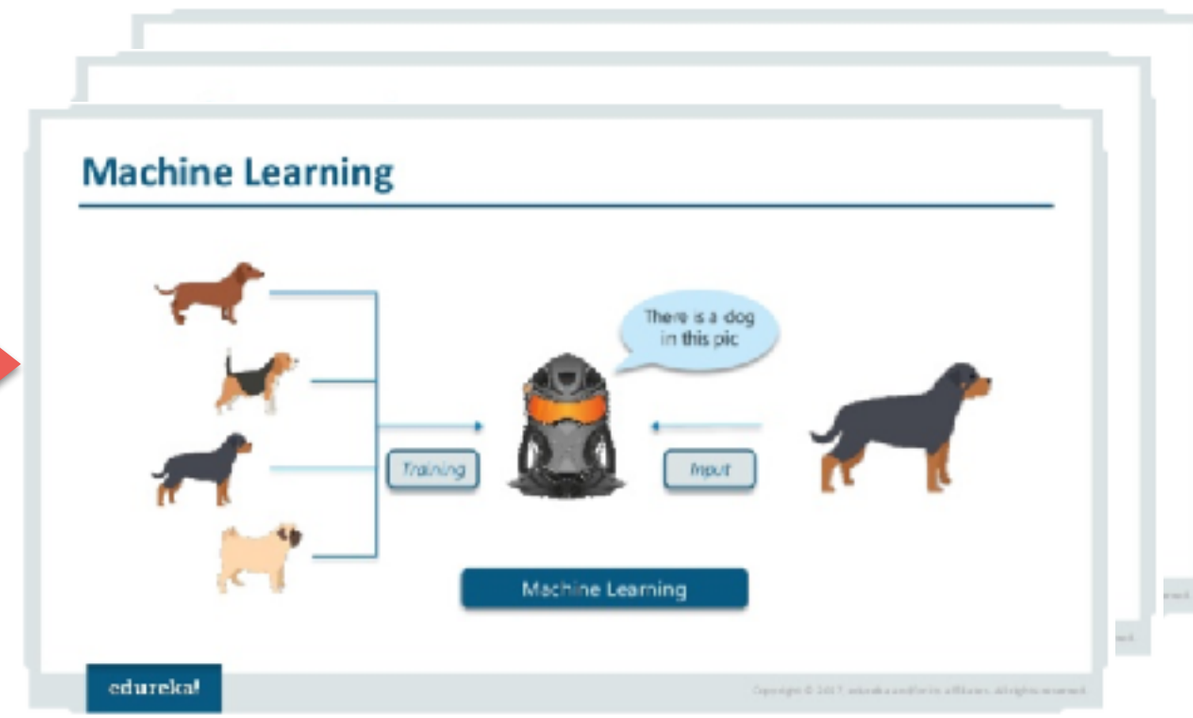

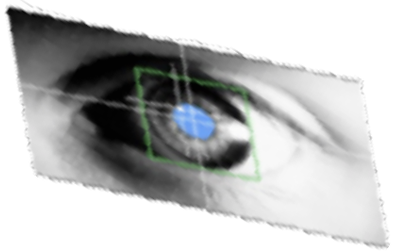

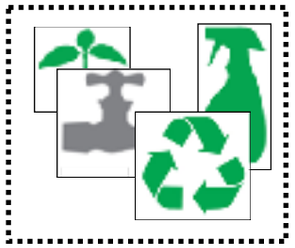

Zoya Bylinskii
CSAIL, EECS, MIT
Thesis Defense Talk

Computational Perception for Multi-Modal Document Understanding

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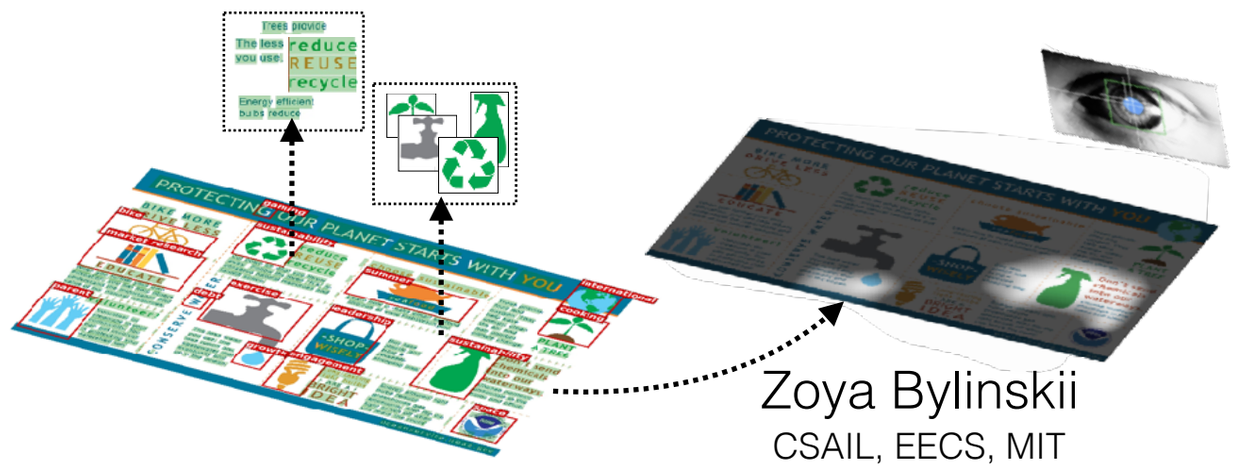

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Approach

PROTECTING OUR PLANET STARTS WITH YOU

BIKE MORE DRIVE LESS

reduce REUSE recycle

Cut down on what you throw away. Follow the three "R's" to conserve natural resources and landfill space.

choose sustainable seafood

Learn how to make smart seafood choices at www.FishWatch.gov.

PLANT A TREE

Trees provide food and oxygen. They help save energy, clean the air, and help combat climate change.

EDUCATE

When you further your own education, you can help others understand the importance and value of our natural resources.

CONSERVE WATER

The less water you use, the less runoff and wastewater that eventually end up in the ocean.

-SHOP- WISELY

Buy less plastic and bring a reusable shopping bag.

Don't send chemicals into our waterways.

Choose nontoxic chemicals in the home and office.

Volunteer for cleanups in your community. You can get involved in protecting your watershed too!

Long-lasting light bulbs - ARE A - BRIGHT IDEA

Energy efficient light bulbs reduce greenhouse gas emissions. Also flip the light switch off when you leave the room!

oceanservice.noaa.gov

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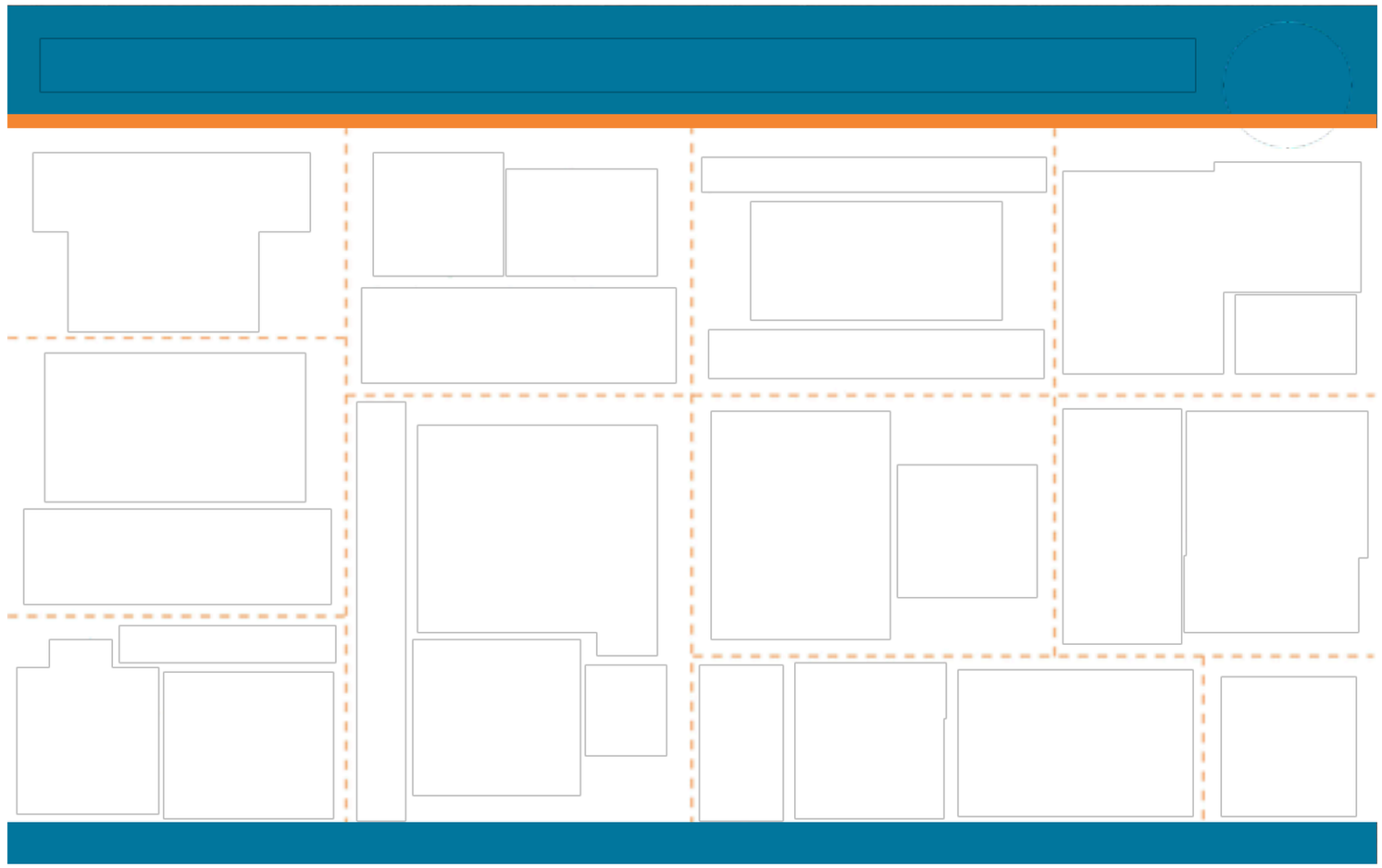

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Results

Multi-modal understanding

Topic prediction

Dense annotation

Attention Modeling

Summarization & Redesign

Multi-modal understanding

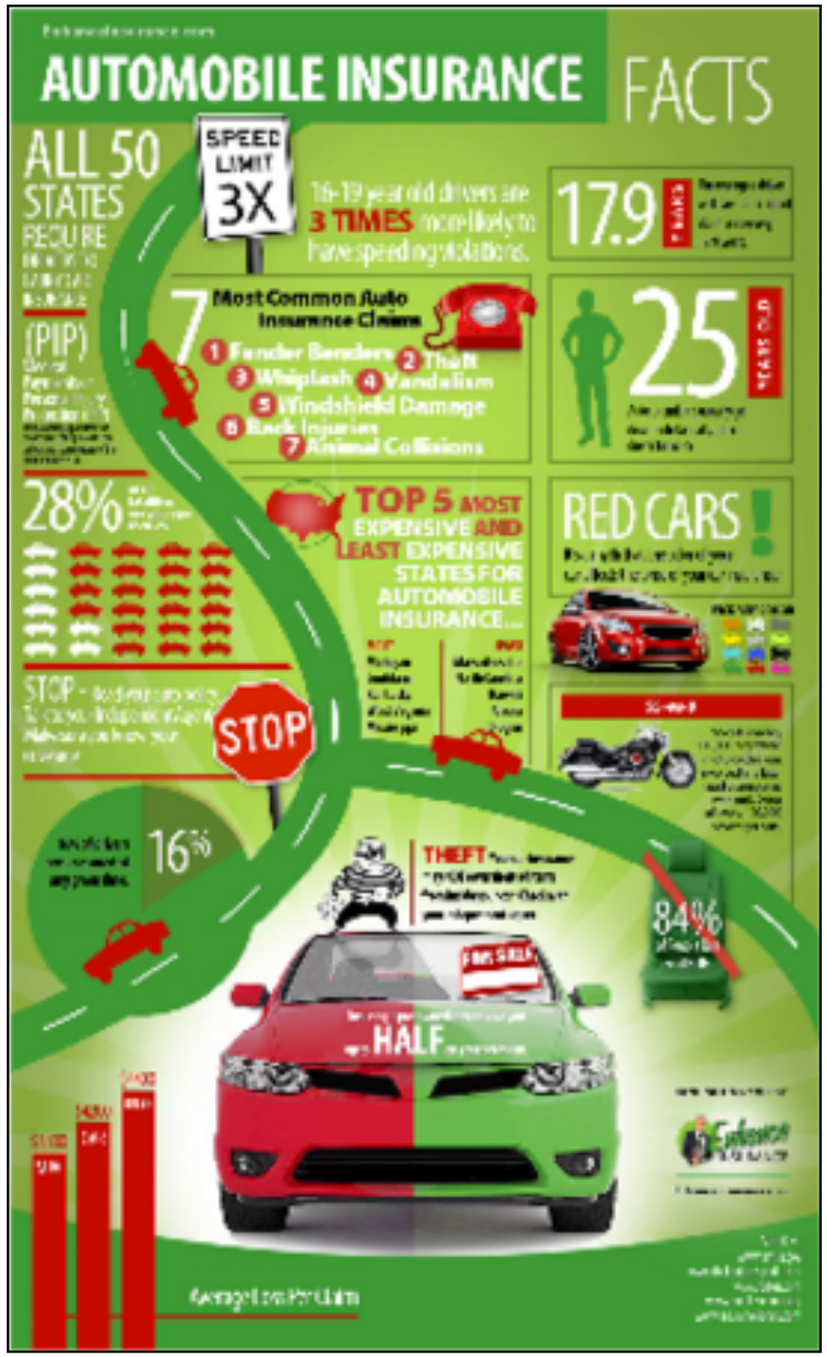
Topic prediction

Dense annotation

Attention Modeling

Summarization & Redesign

Visually dataset



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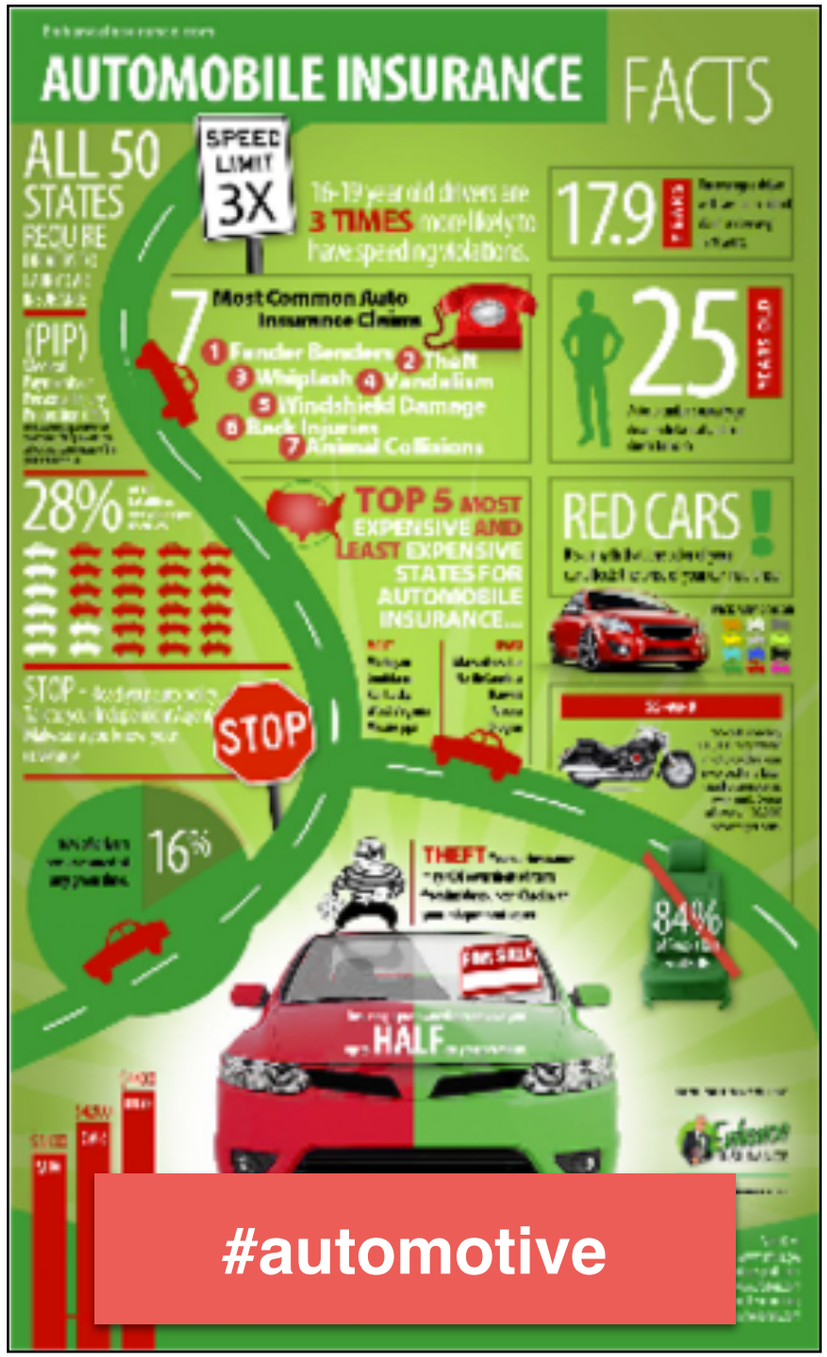

#automotive

#insect

#farming

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Visually dataset

infographics tell stories with data

Bylinskii*, Alsheikh*, Madan*, Recasens* et al. [arXiv 2017]

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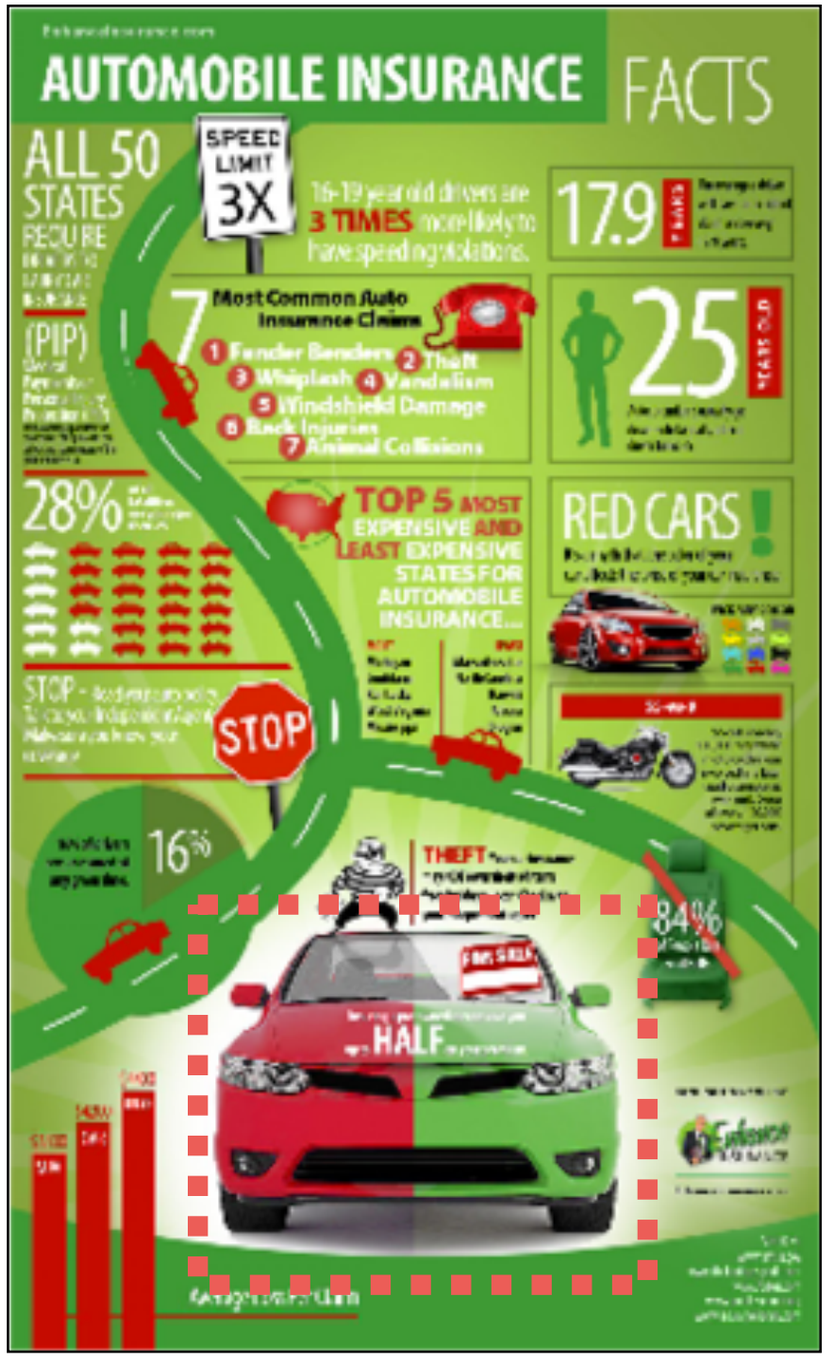

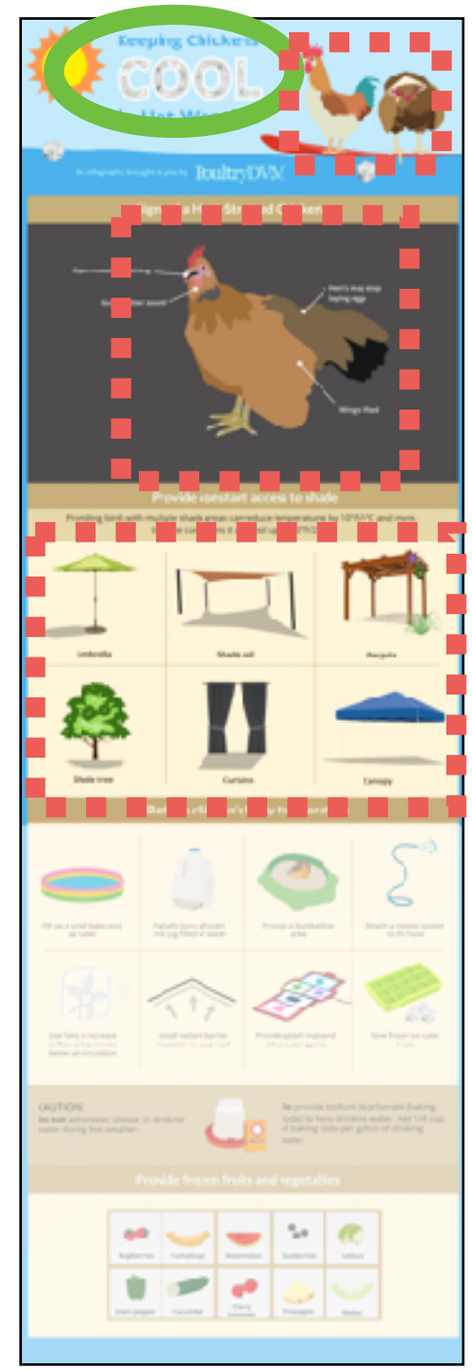

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The World as 100 People

shared by JackHagley on Mar 25, 2013 in Geography

870,376	211	82
views	faves	comments

The World as 100 People. This idea has been around since 1990. This is my attempt at presenting the information.

Tags: infographic, infographics, geography, people, demographics, demography

Source: http://www.1...0stats.php

Category: Geography

Designer:
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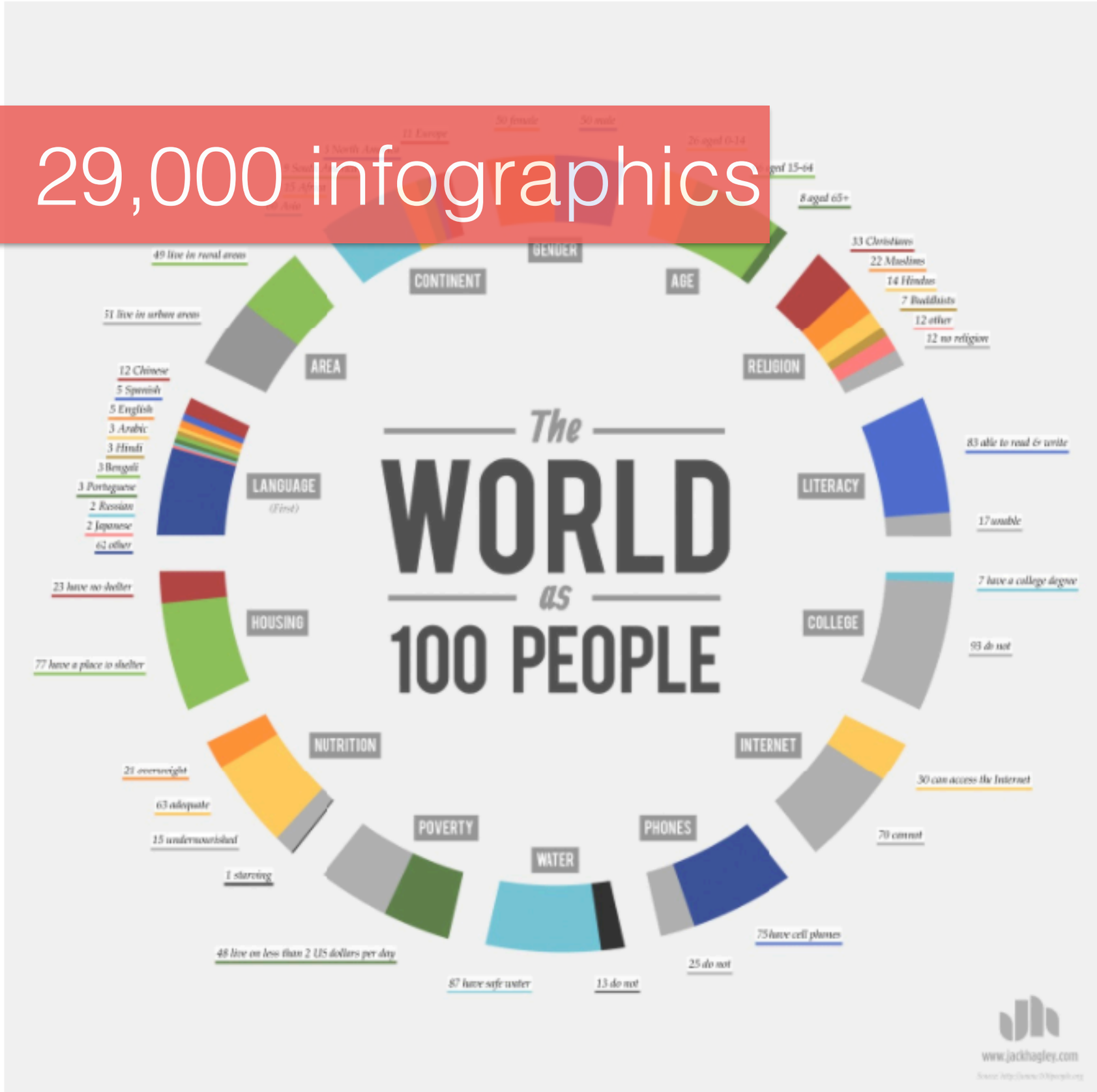

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391 topics

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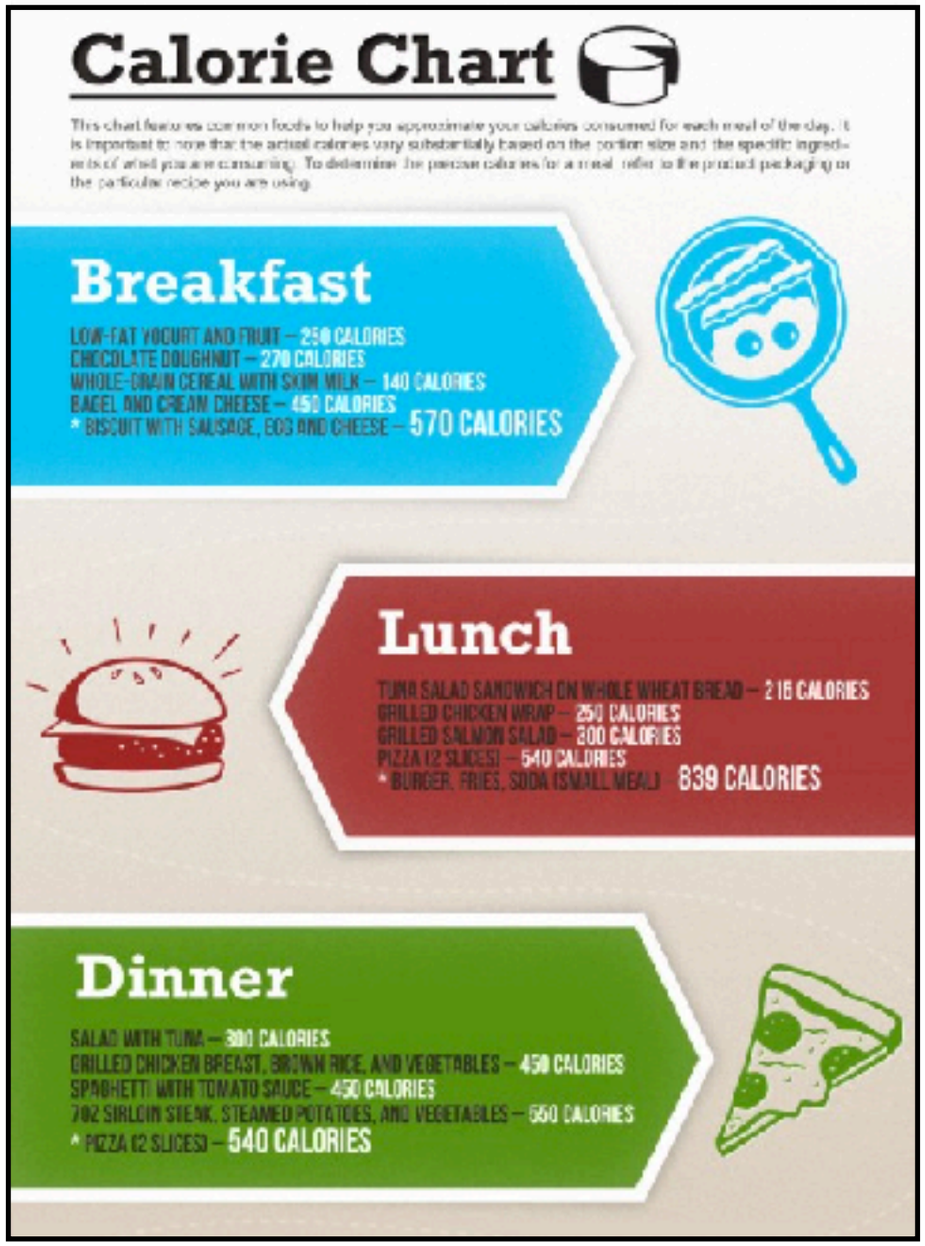
Topic prediction

#food



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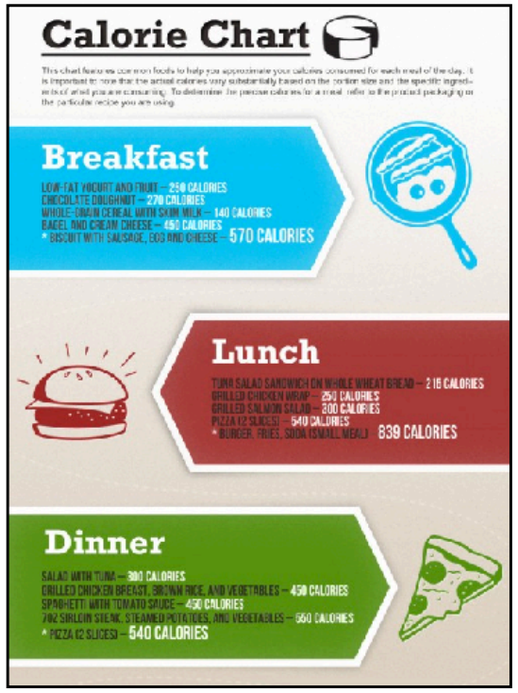

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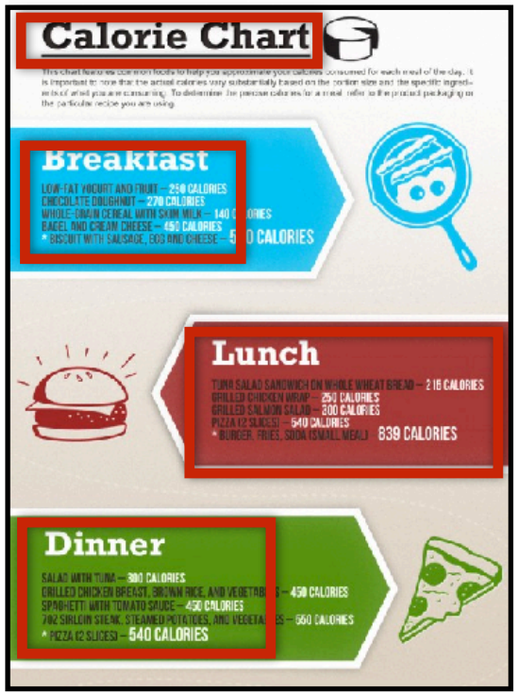

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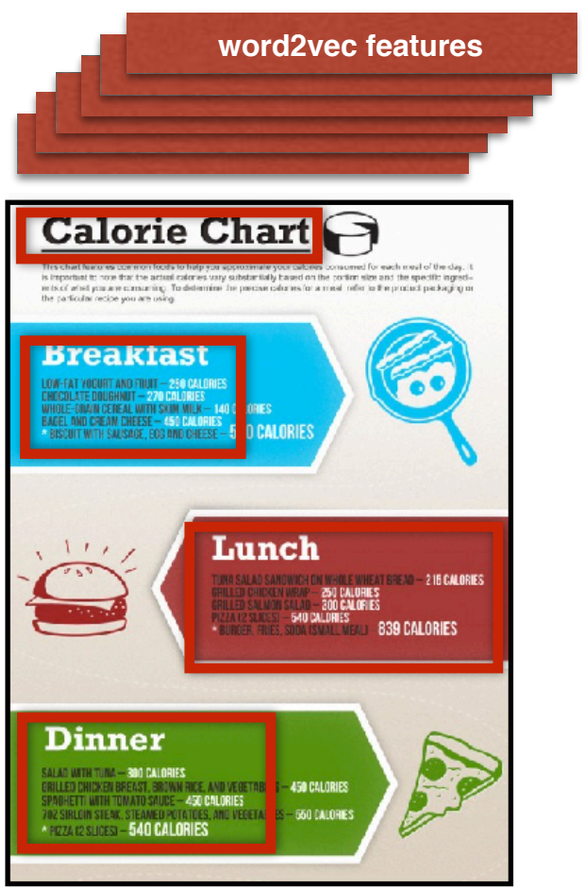

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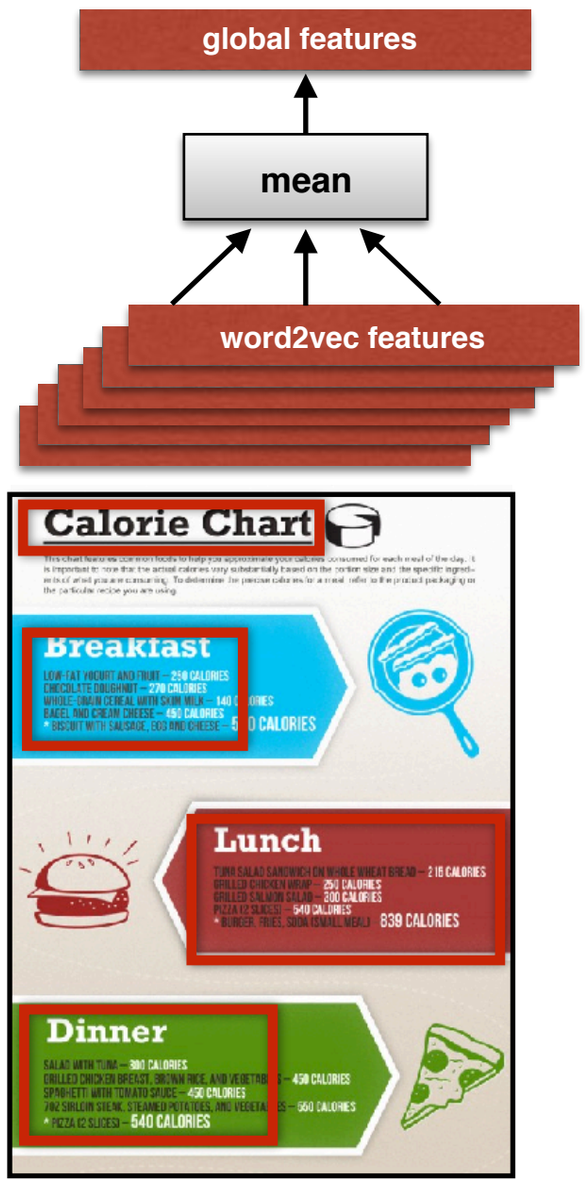

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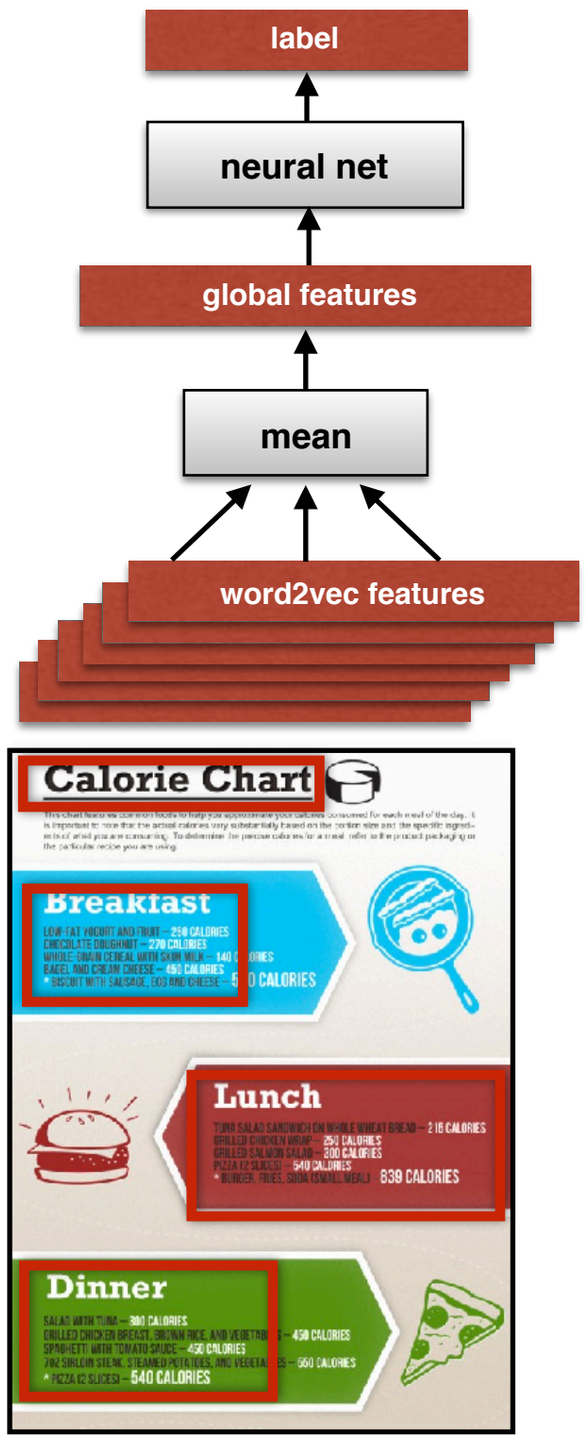

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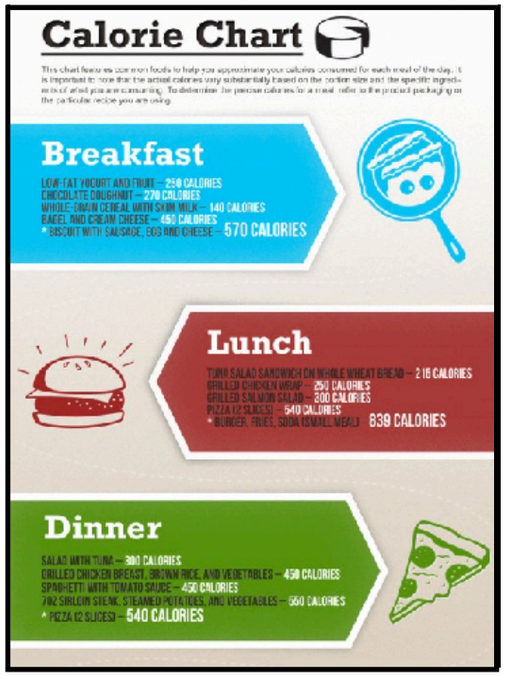

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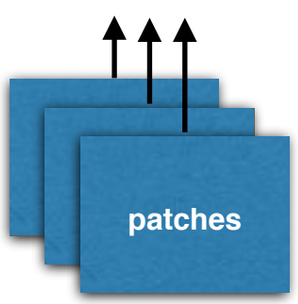

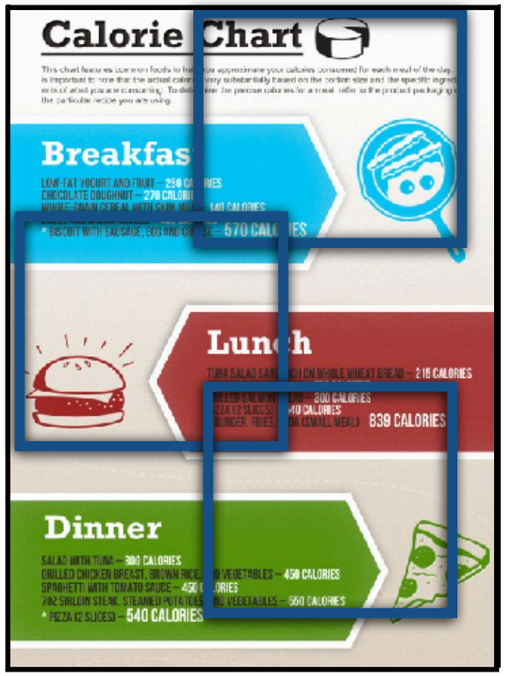

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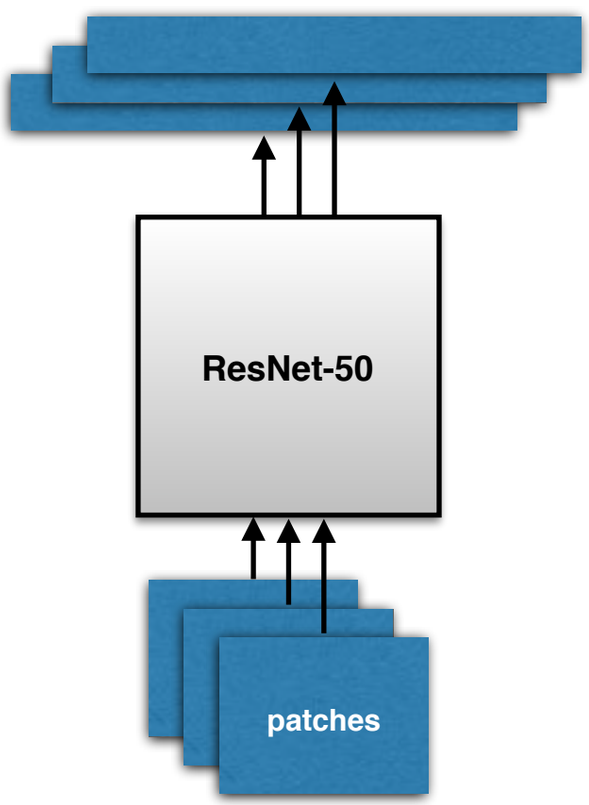

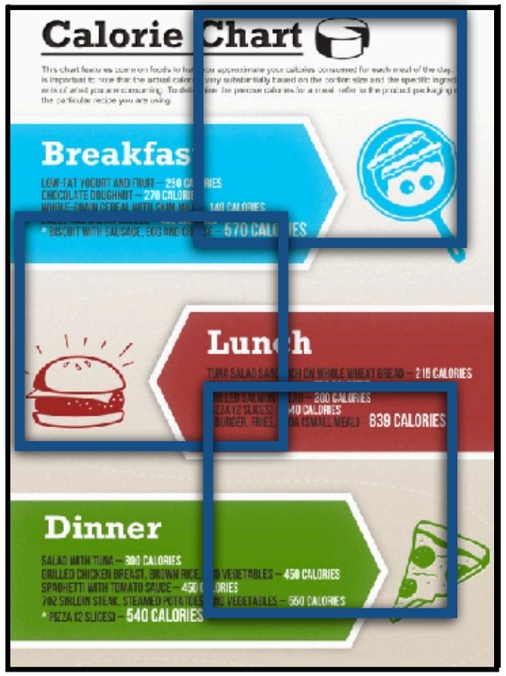

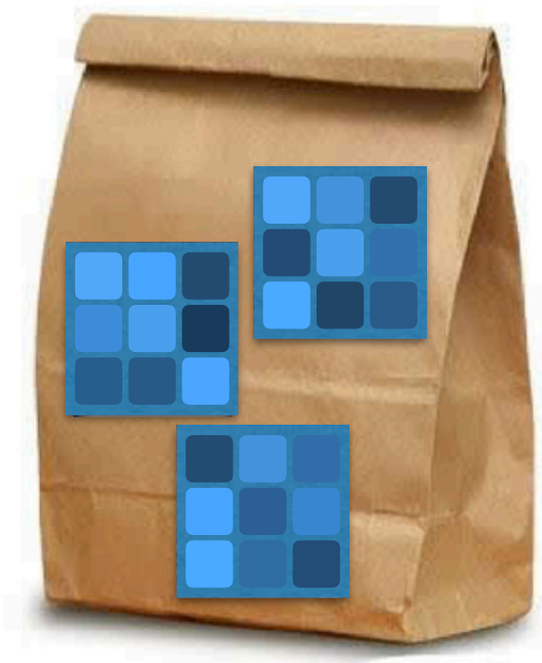

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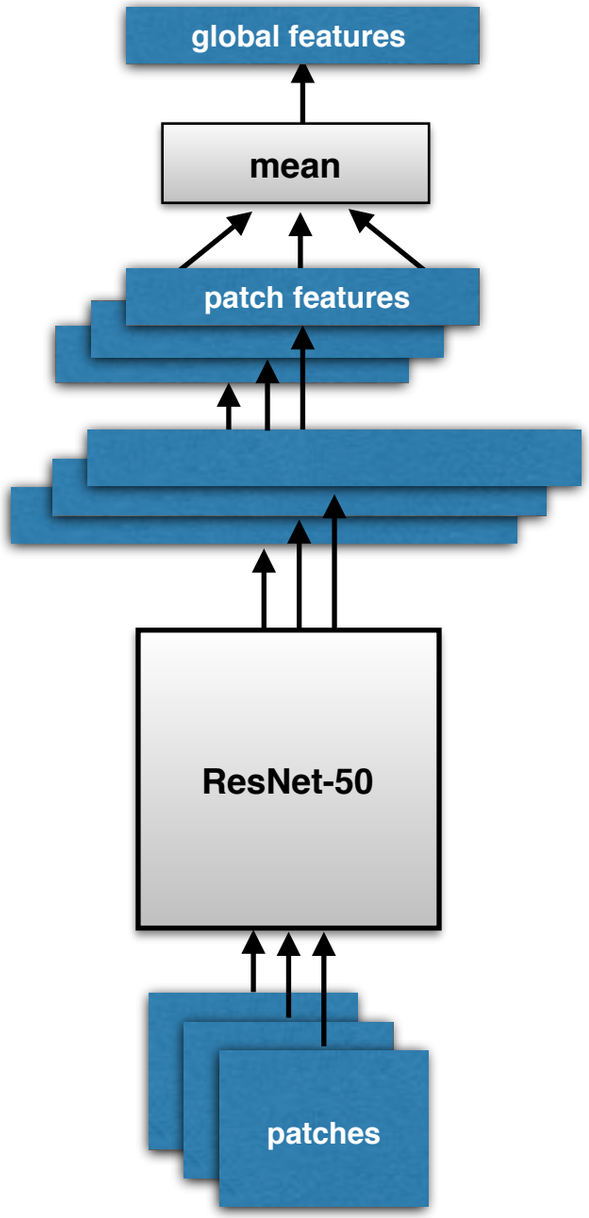

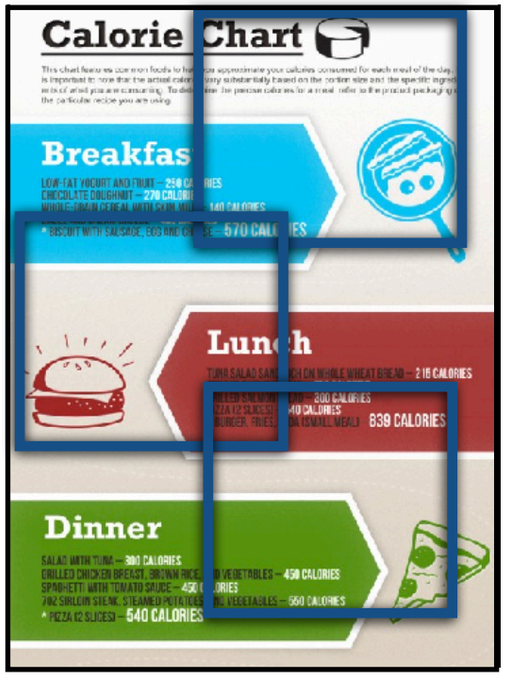

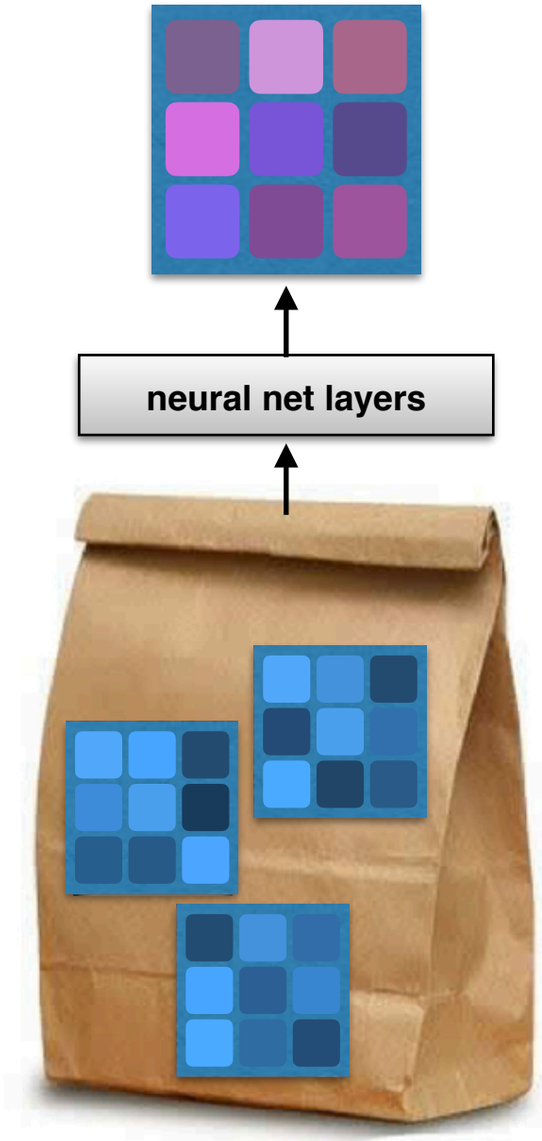

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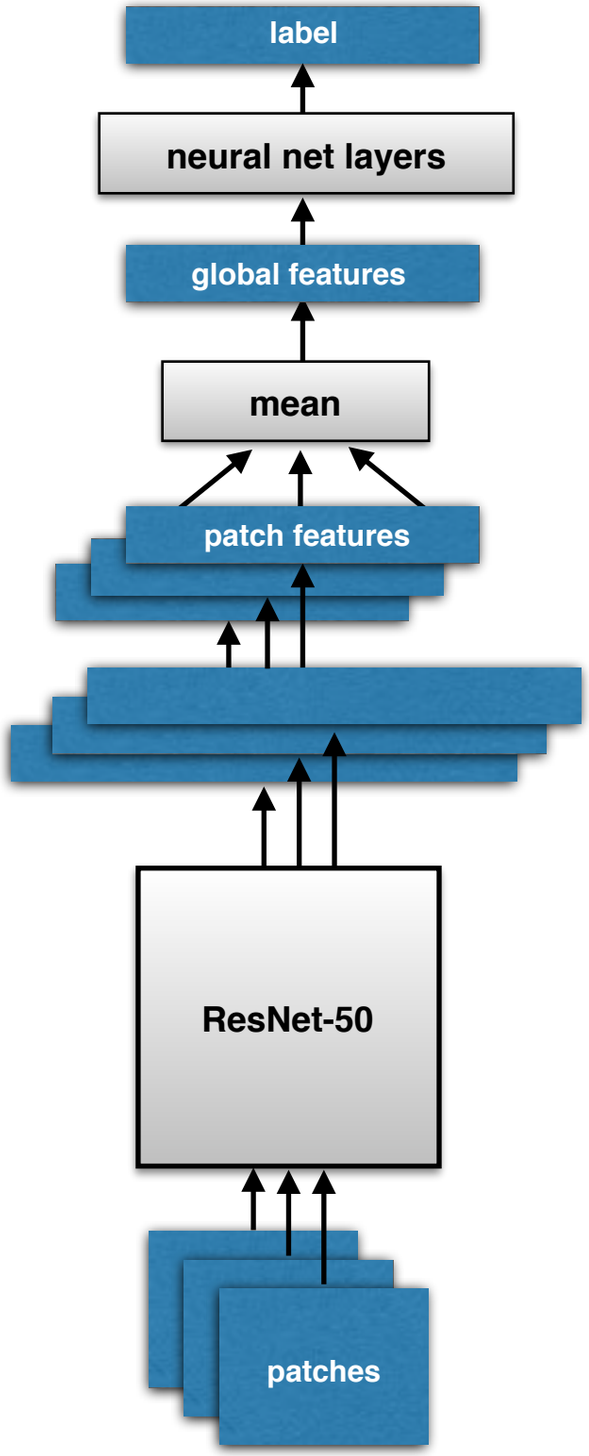

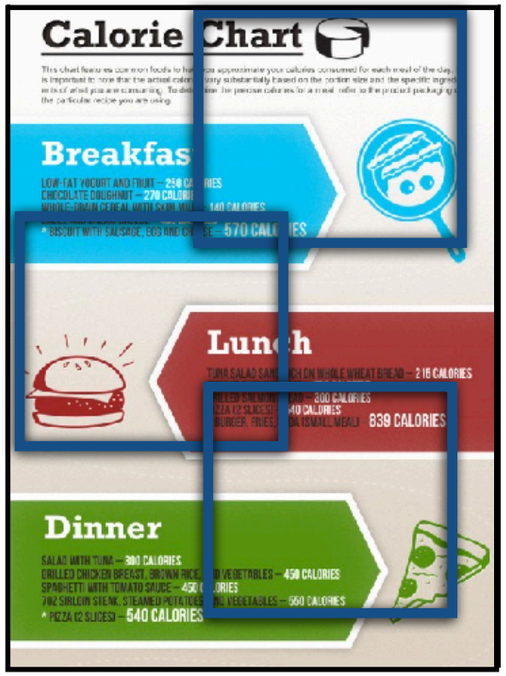

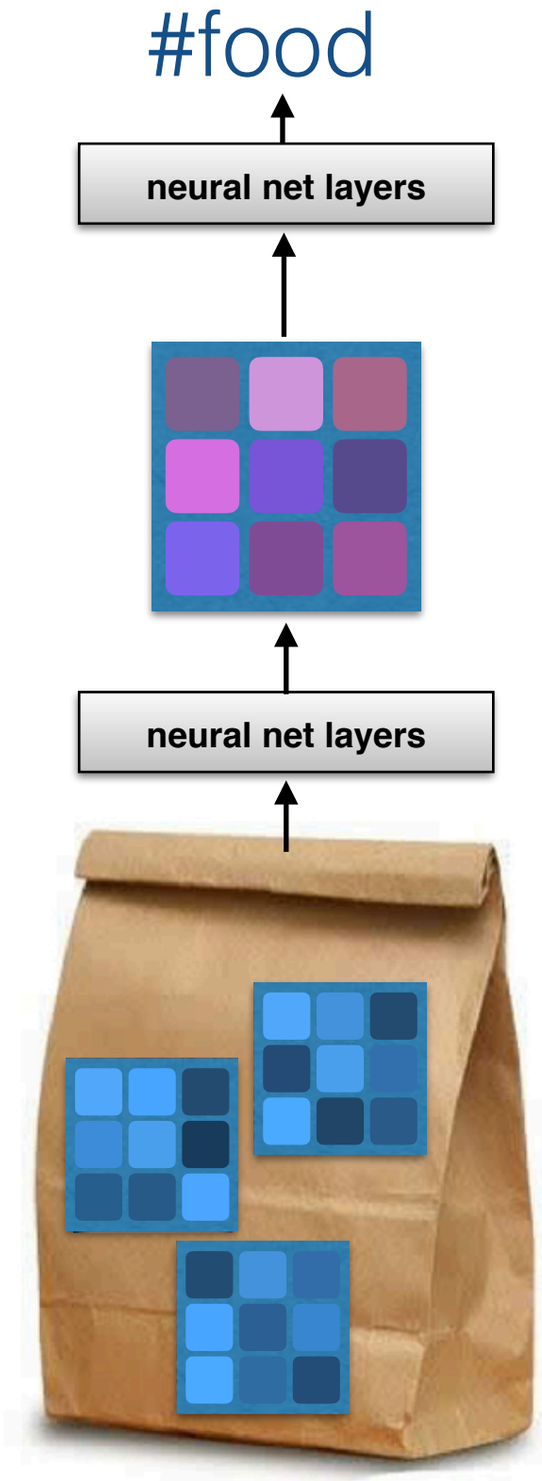

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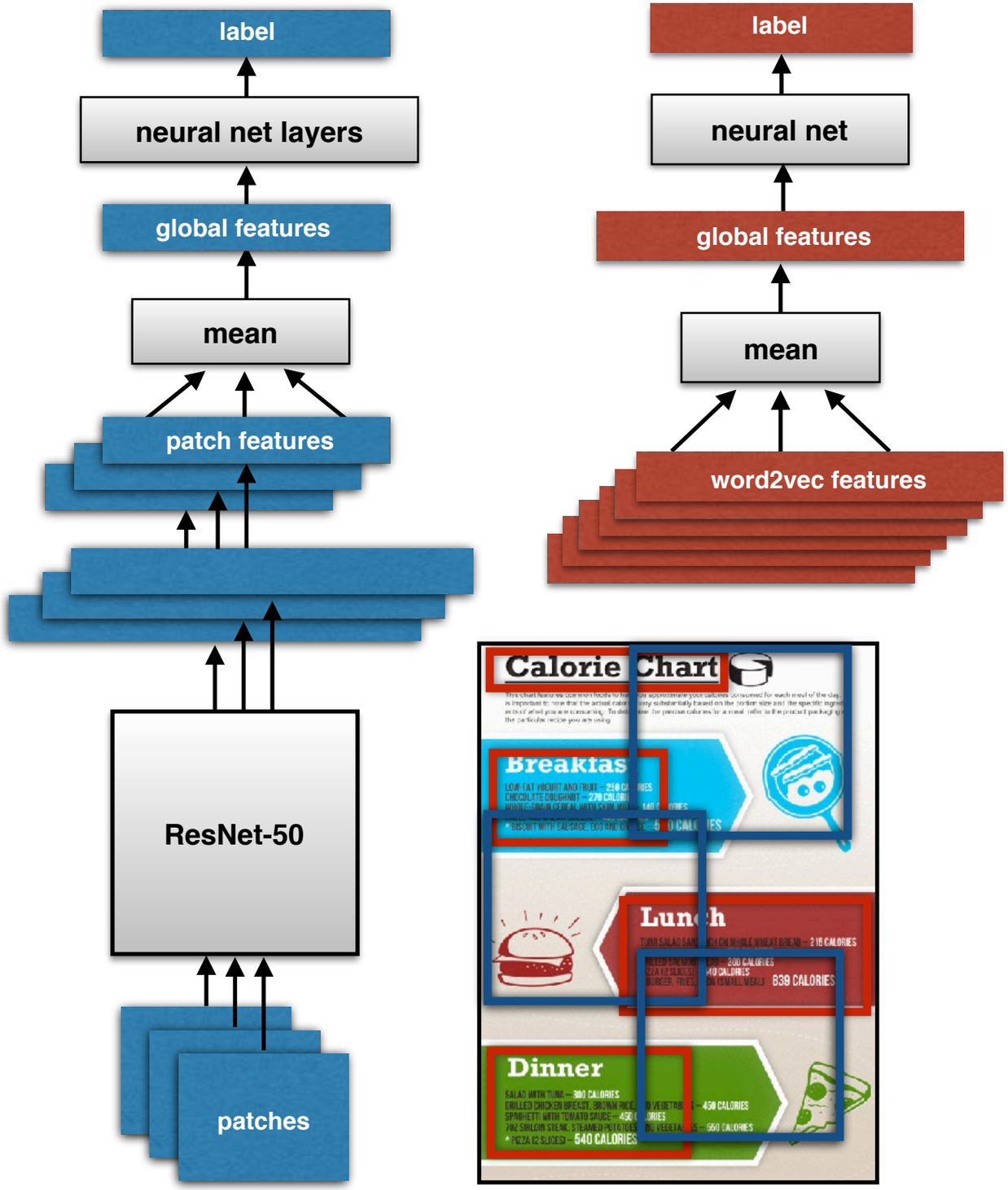

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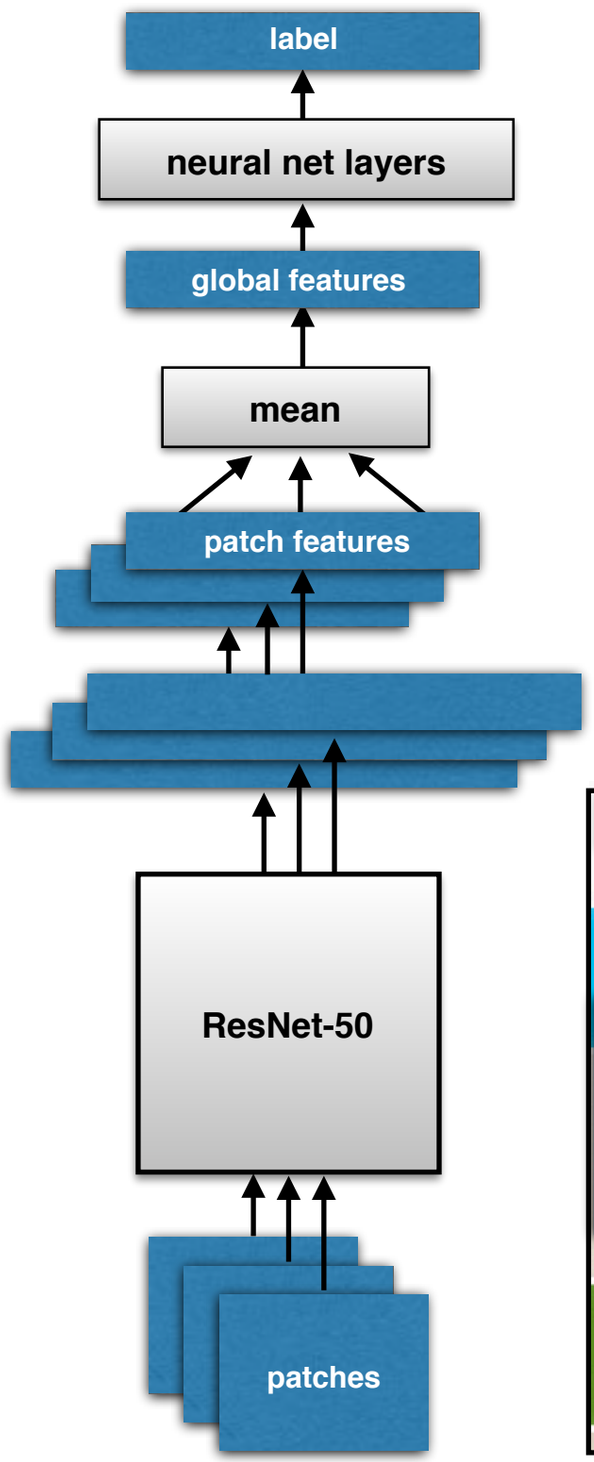

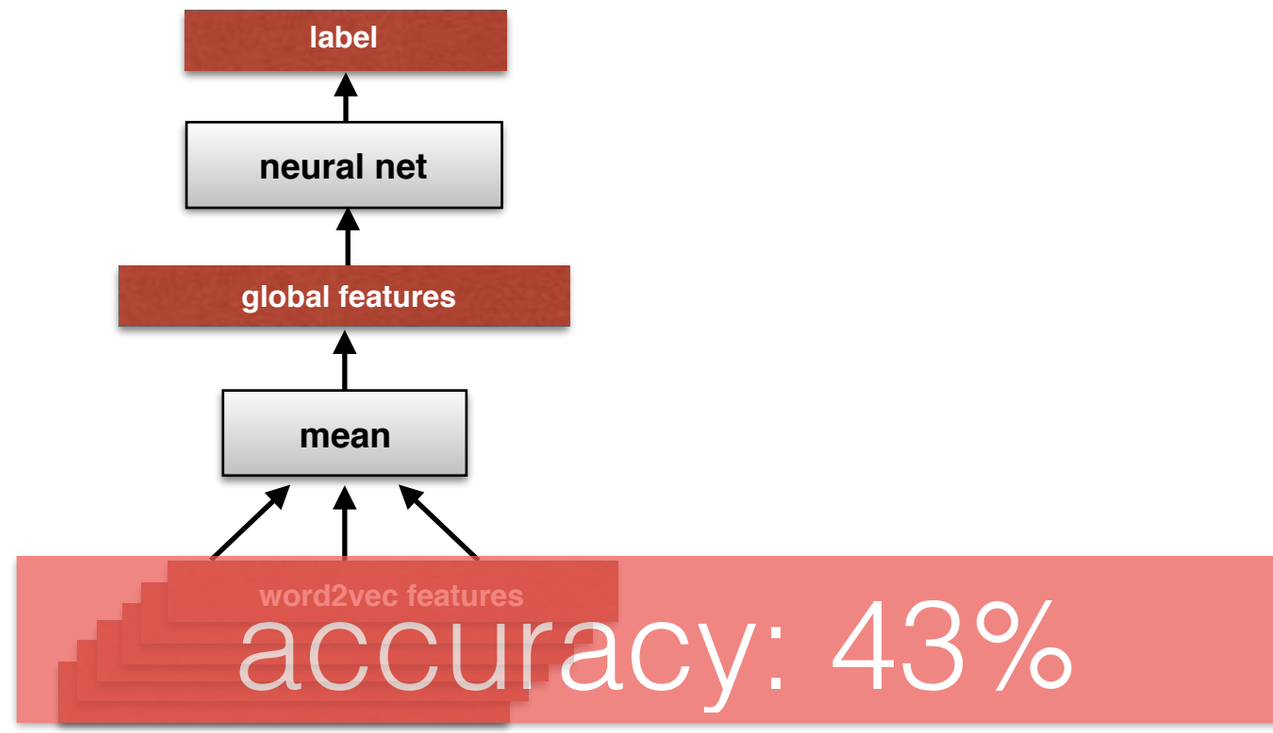

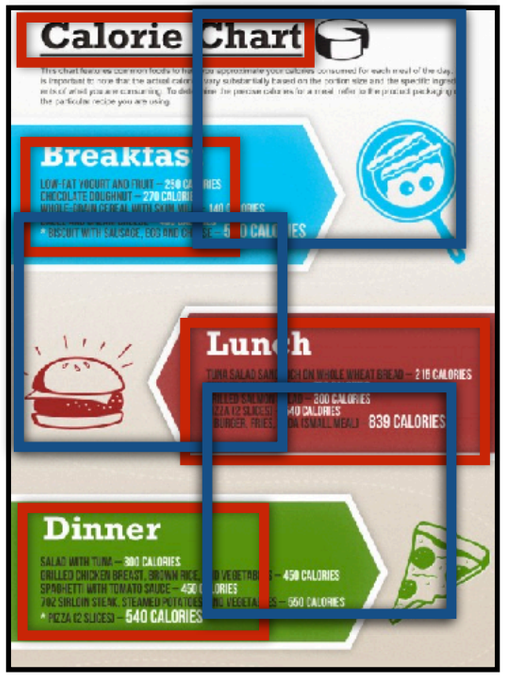

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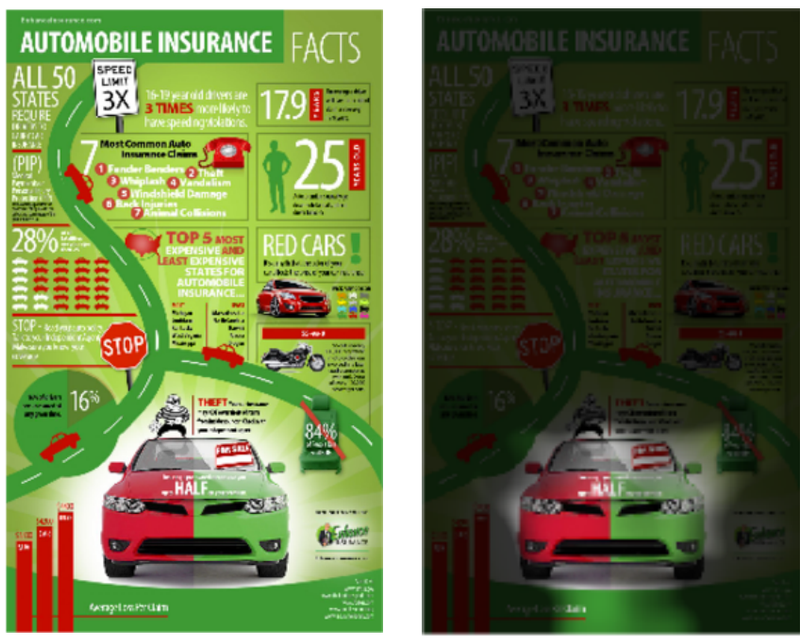

#football

#food

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Topic prediction

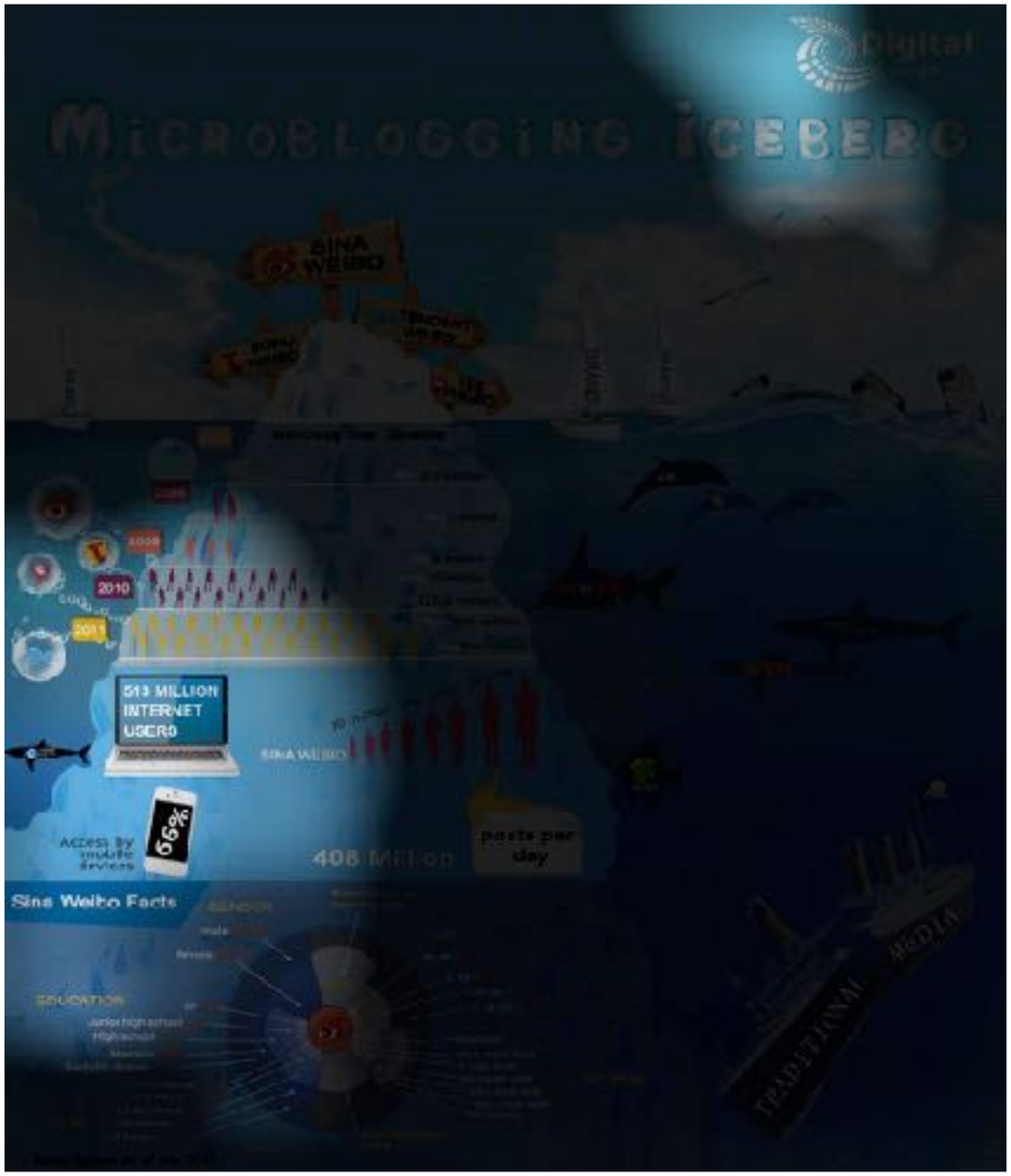
Topic prediction

#travel

Topic prediction

#social media

Topic prediction



#social media

Future Work

A visual metaphor of an iceberg is invoked to show that the common blogging sites are only the tip of the micro-blogging iceberg.

Future Work

A visual metaphor of an iceberg is invoked to show that the common blogging sites are only the tip of the micro-blogging iceberg.

Future Work

A visual metaphor of an iceberg is invoked to show that the common blogging sites are only the tip of the micro-blogging iceberg.

Multi-modal understanding

Topic prediction

Dense annotation

Attention Modeling

Summarization & Redesign

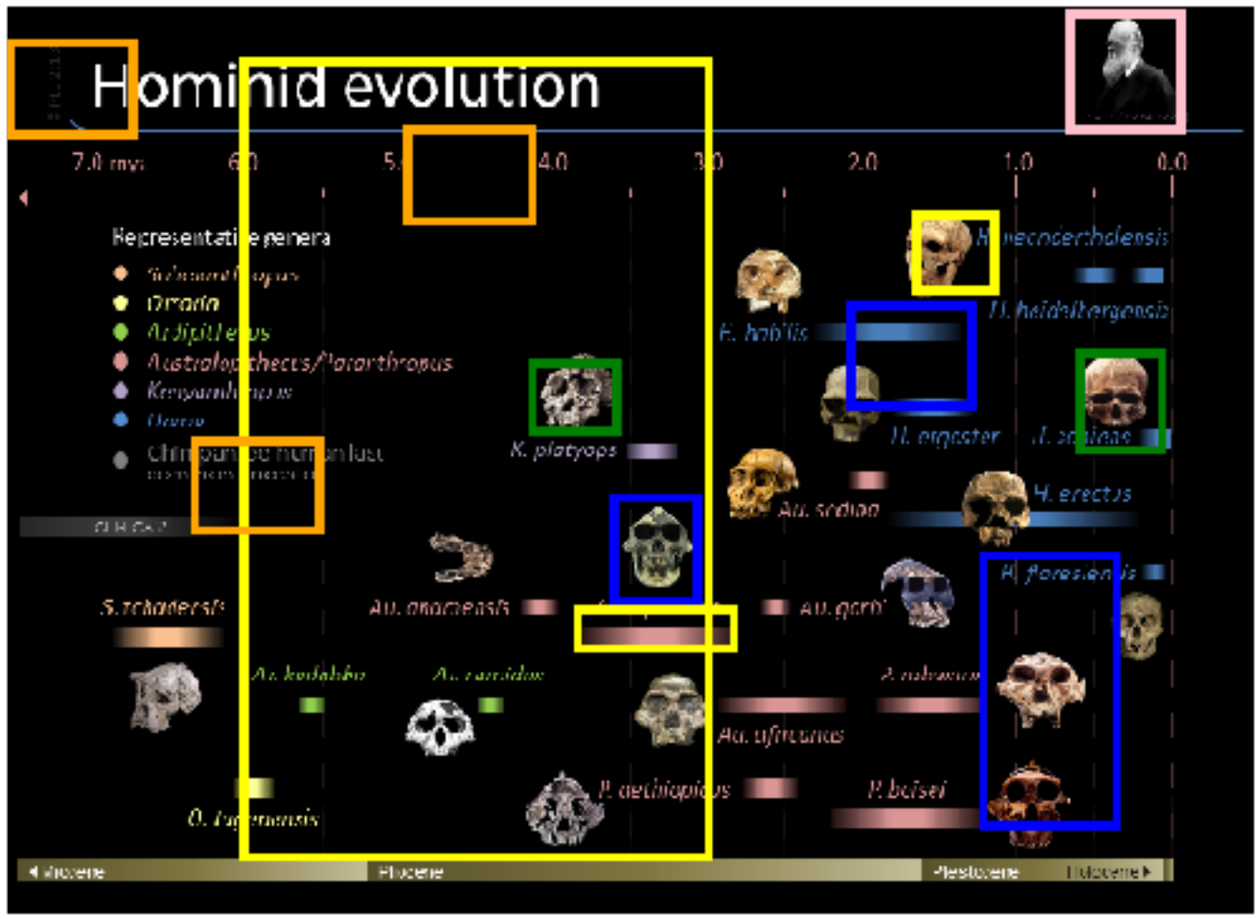
Multi-modal understanding

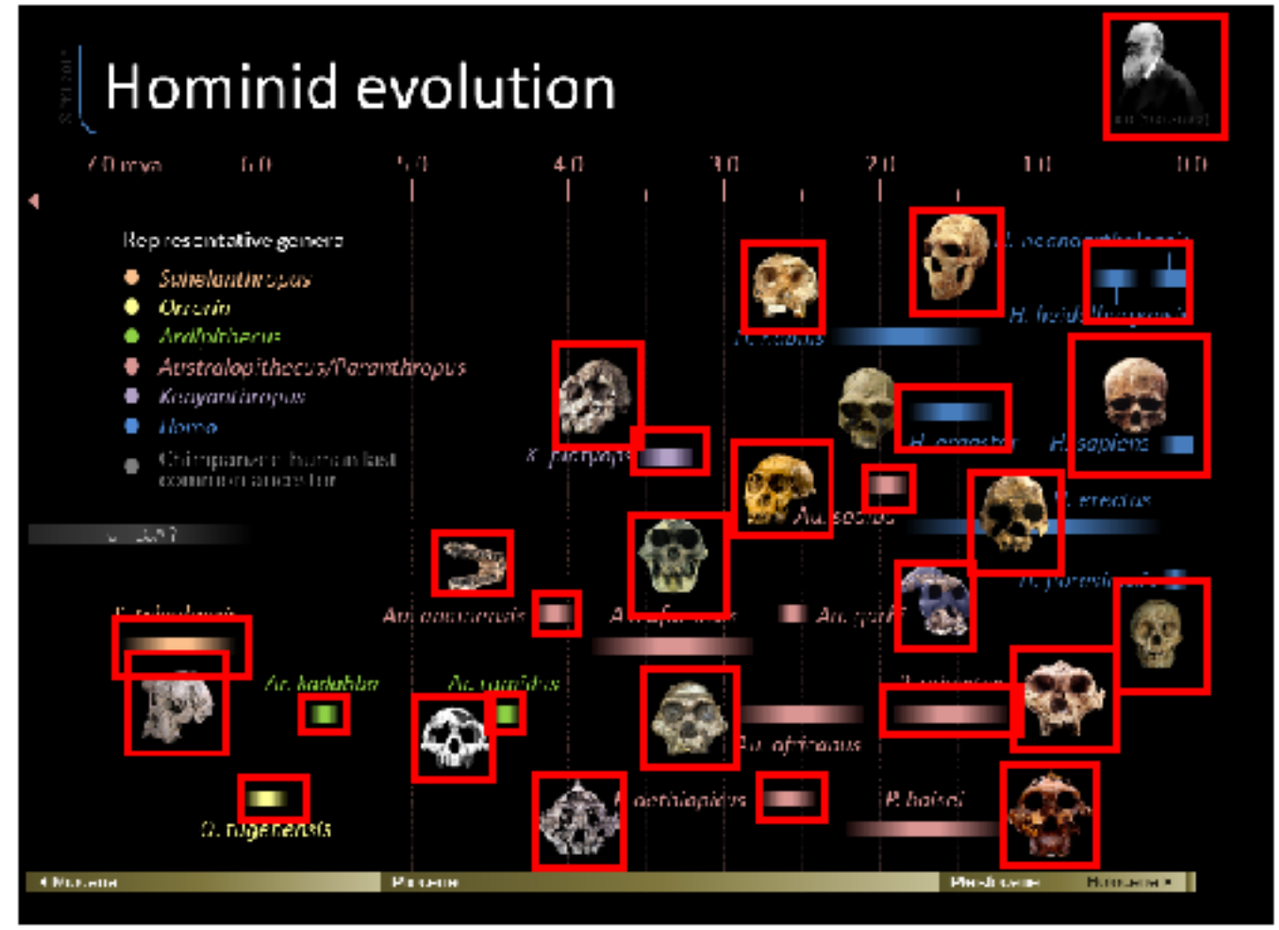
Dense annotation

Dense annotation

Bylinskii*, Madan*, Tancik* et al. [under review]

Icon detection





YOLOv2

Objectness

SSD

SharpMask

Faster R-CNN

Our model

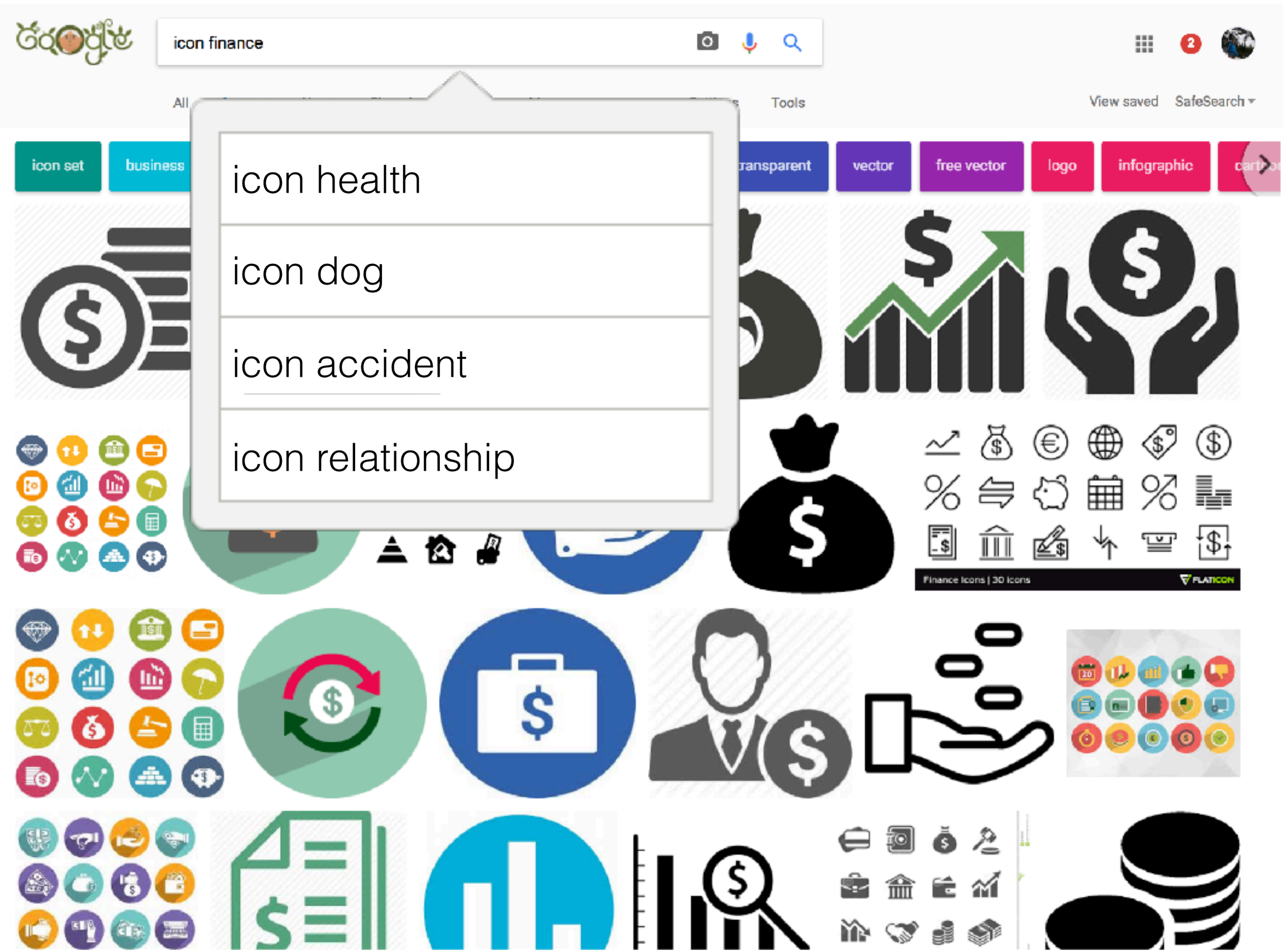
Bylinskii*, Madan*, Tancik* et al. [under review]

AUTOMOBILE INSURANCE FACTS
ALL 50 STATES
SPEED LIMIT 3X
3 TIMES
Most Common Auto Insurance Claim
Fender Benders
Whiplash
Windshield Damage
Back Injuries
Animal Collisions
(PIP)
28%
16%
STOP
THEFT
HALF
Mexican Redknee Tarantula
www.SpidersWorlds.com
Leg span:
6 inches (15.24 cm.)
Weight:
0.53 Ounces (15 gra)
Life expectancy:
25-30 years females.
Males rarely live longer than 10 years.
Age of sexual maturity:
Female: 6-7 years.
Male: 4 years.
Incubation time:
9 weeks.
Number of offspring:
200 to 400.
Scientific Name:
Brachypelma smithi.
Habitat:
Deciduous tropical forests.
Deserts.
Rocky areas.
Distribution:
Predators:
Birds.
Moths.
Lizards.
Diet:
Insects.
Frogs.
COOL
Hot Weather
Signs of a Heat-Stressed Chicken
ECO FRIENDLY ROOFING
RECYCLED RUBBER ROOF SHINGLES
STANDING SEAM METAL ROOFING
GREEN ROOFING
Peterson Roofing

icon finance

All | Images | News | Shopping | Maps | More | Settings | Tools | View saved | SafeSearch

icon set | business | financial | money | financial service | income | mobile | transparent | vector | free vector | logo | infographic | cartoon

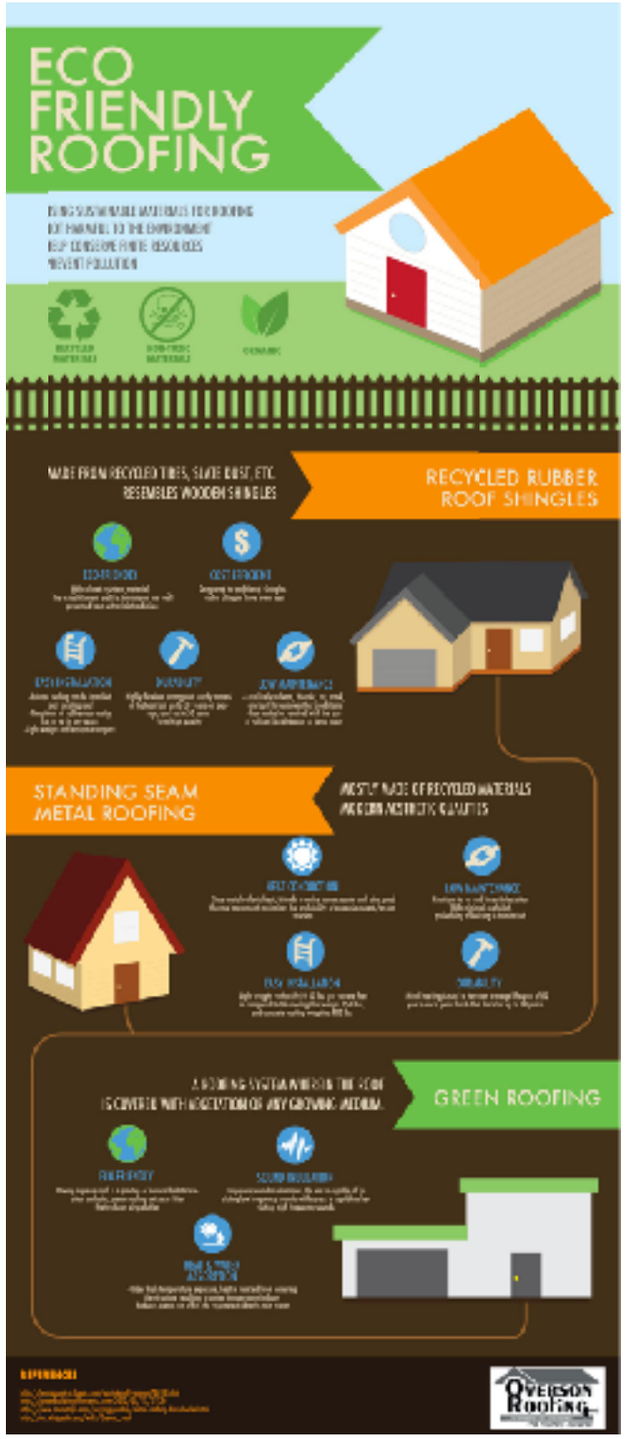

icon finance
All
Tools
View saved
SafeSearch
icon set
business
transparent
vector
free vector
logo
infographic
icon health
icon dog
icon accident
icon relationship
Finance Icons | 30 Icons
FLATICON

icon finance

All | Images | News | Shopping | Maps | More | Settings | Tools | View saved | SafeSearch

icon set | business | financial | money | financial service | income | mobile | transparent | vector | free vector | logo | infographic | cartoon

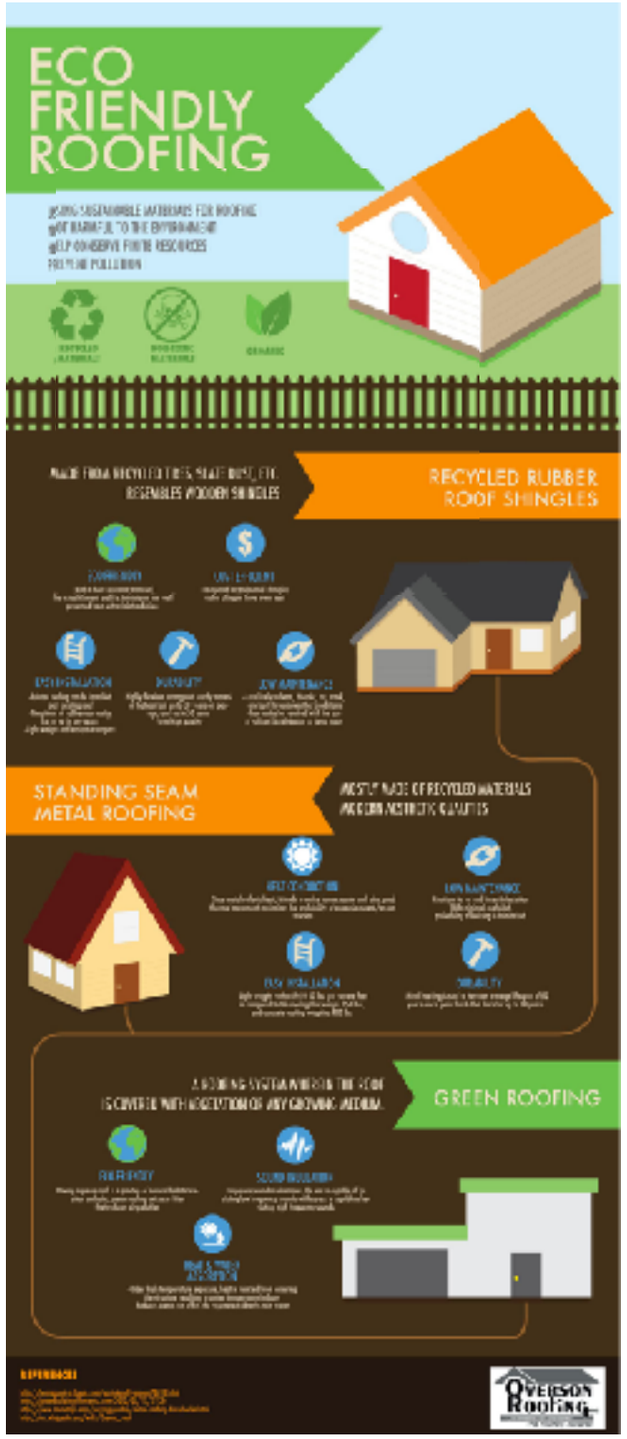
Synthetic data generation



Google-scraped icons

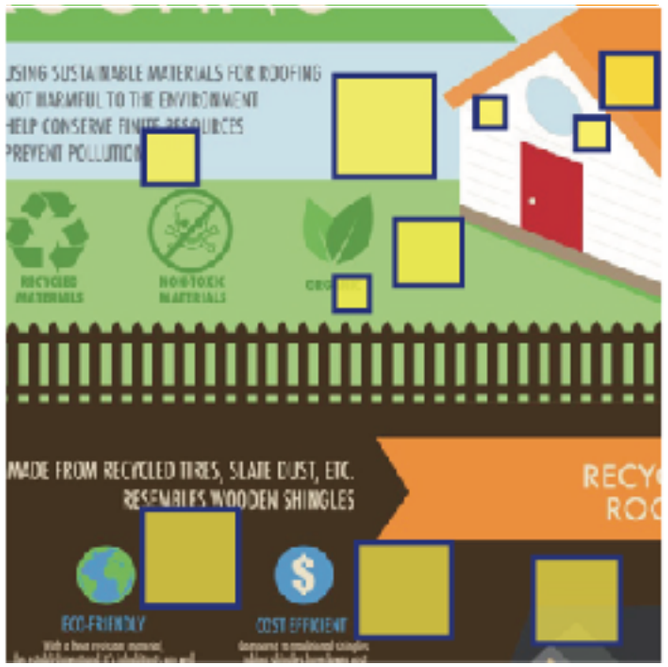
Bylinskii*, Madan*, Tancik* et al. [under review]

Synthetic data generation



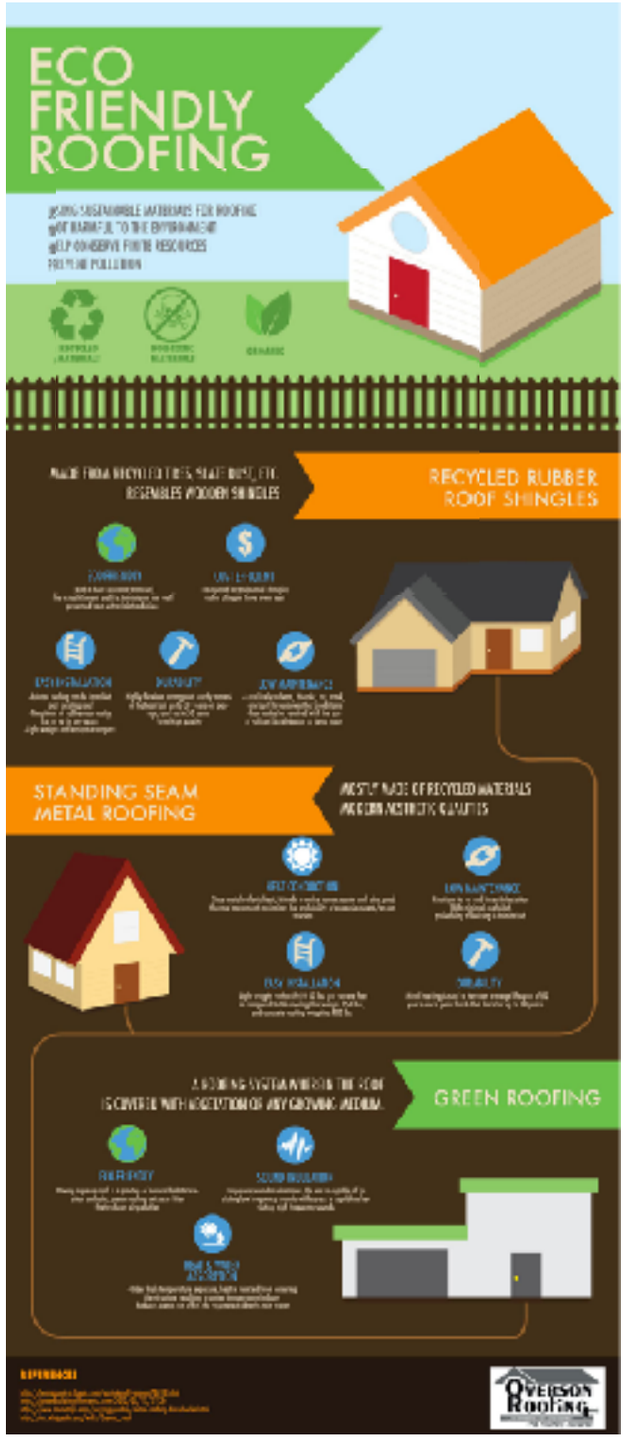
Google-scraped icons

Sampled patches



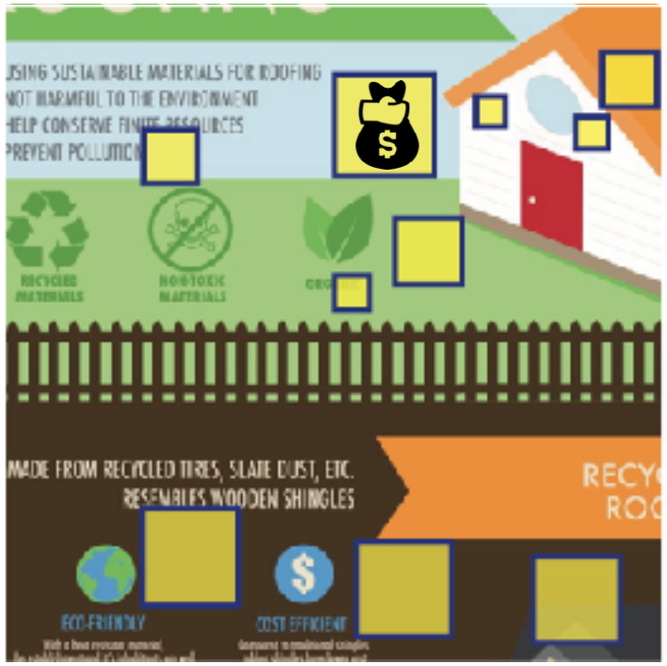
Bylinskii*, Madan*, Tancik* et al. [under review]

Synthetic data generation



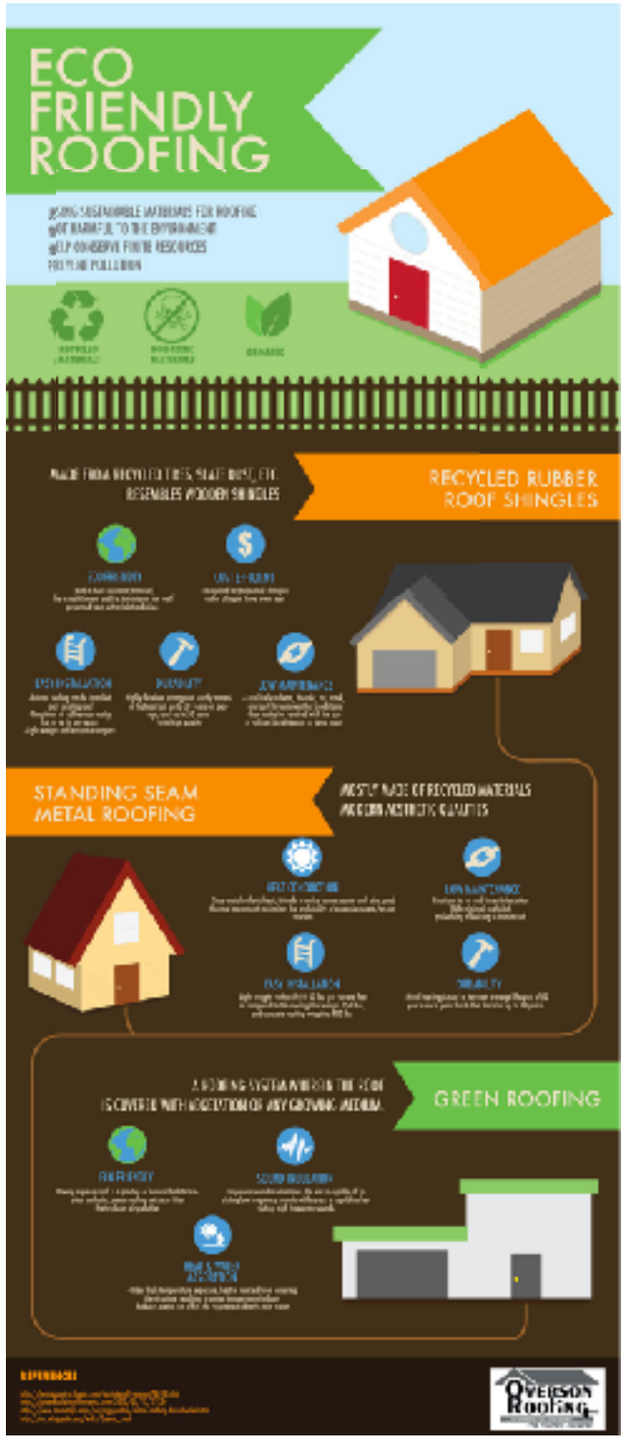
Google-scraped icons

Sampled patches



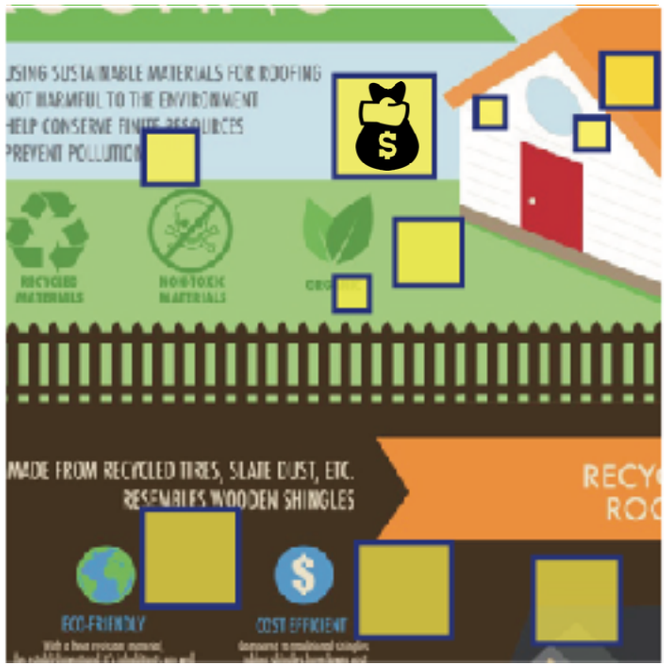
Bylinskii*, Madan*, Tancik* et al. [under review]

Synthetic data generation

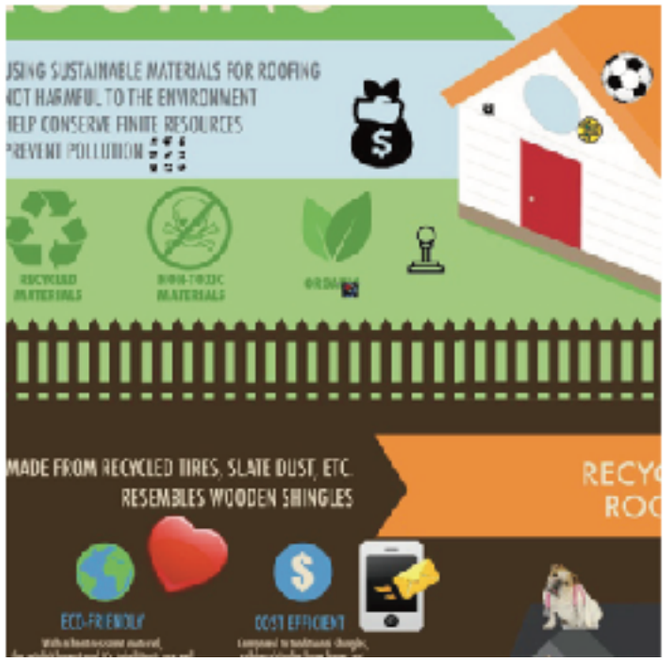


Google-scraped icons

Sampled patches

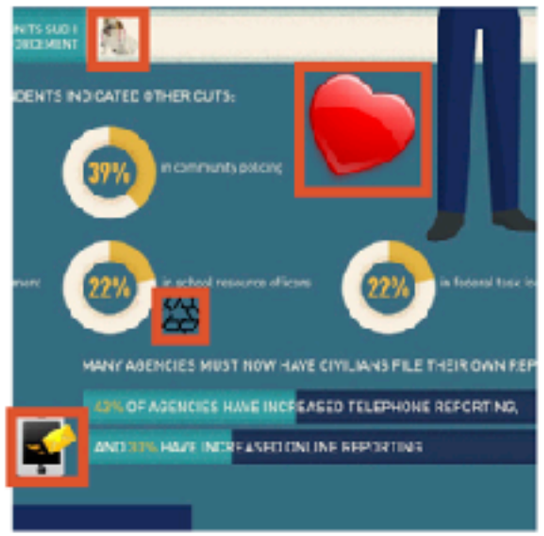


Augmented patches



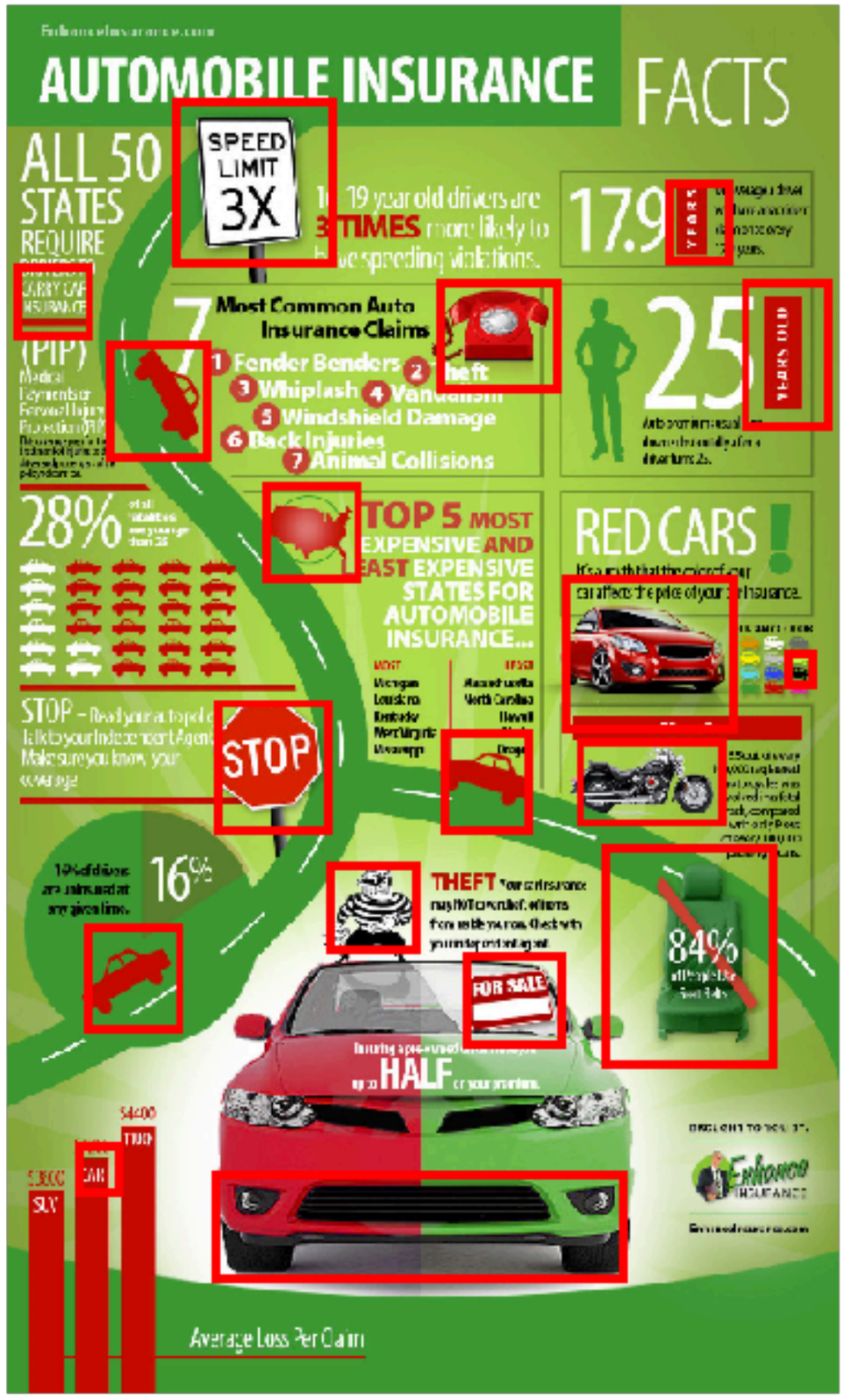
Bylinskii*, Madan*, Tancik* et al. [under review]

Model training



Faster R-CNN Detector

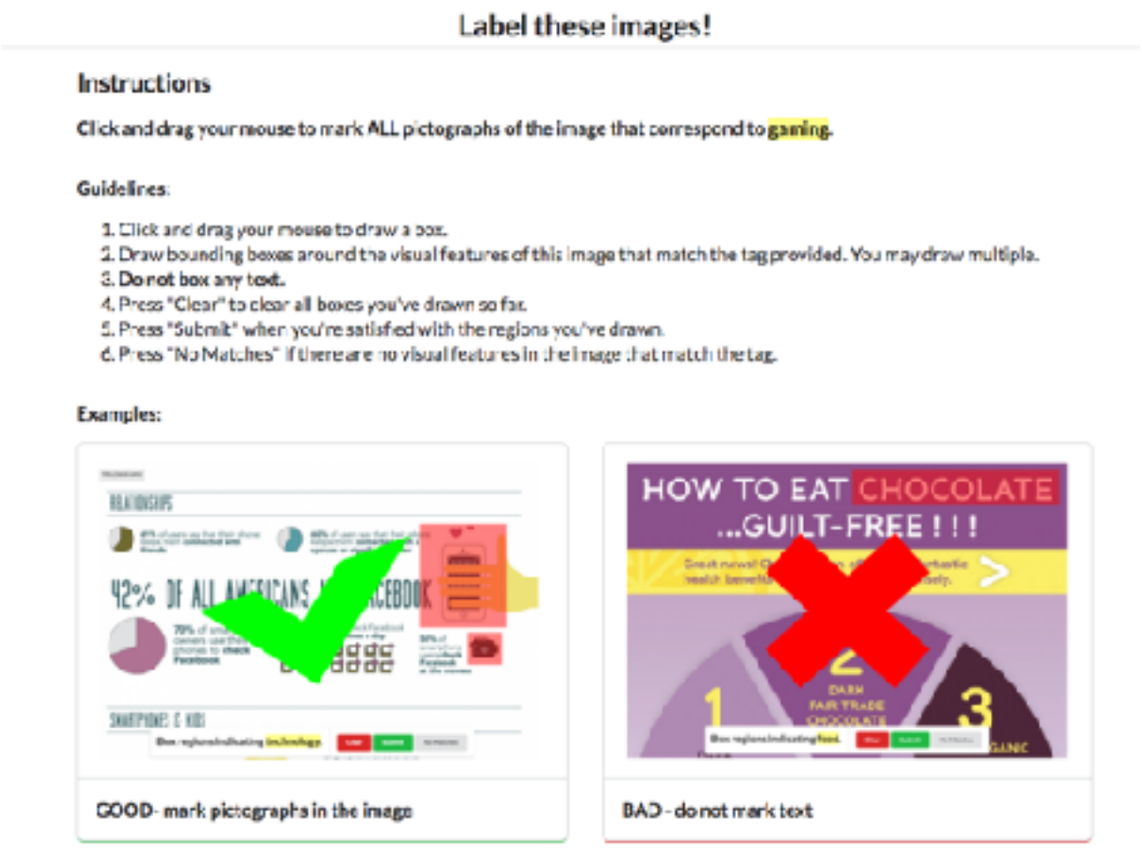
Bylinskii*, Madan*, Tancik* et al. [under review]

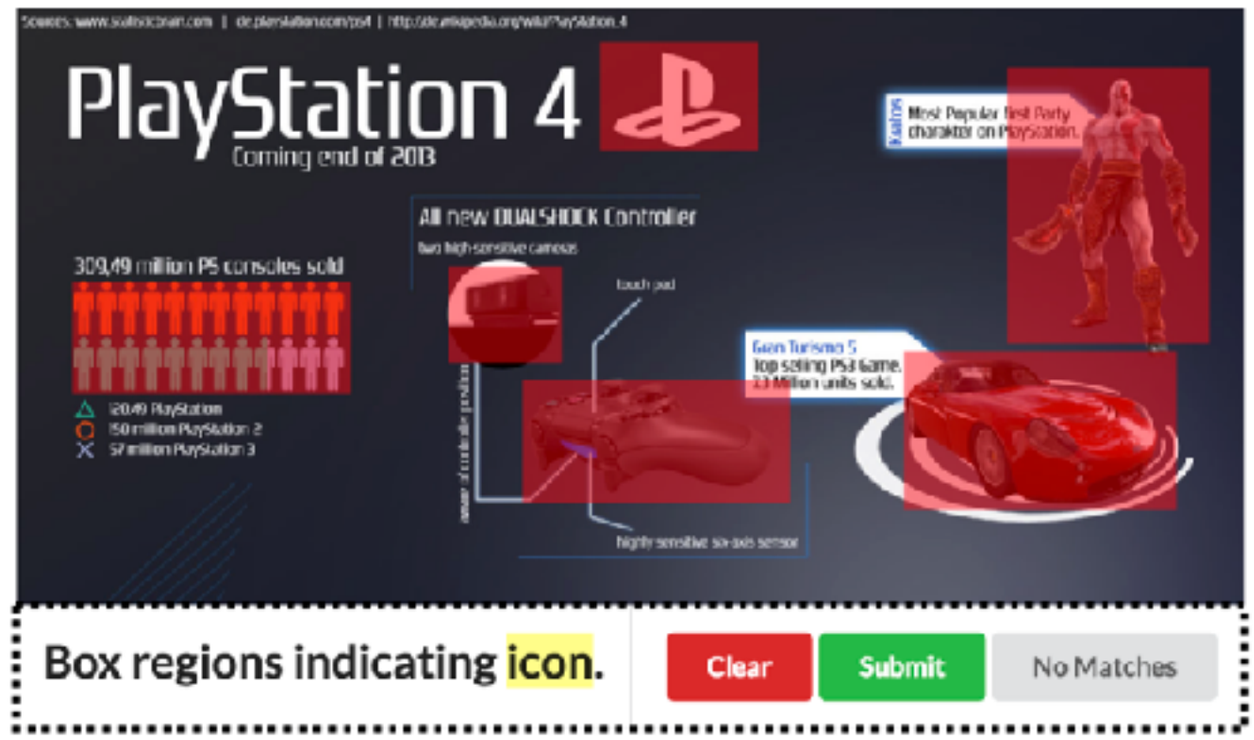

AUTOMOBILE INSURANCE FACTS
ALL 50 STATES REQUIRE
SPEED LIMIT 3X
19 year old drivers are 3 TIMES more likely to have speeding violations.
17.9
7 Most Common Auto Insurance Claims
1 Fender Benders
2 Theft
3 Whiplash
4 Vandalism
5 Windshield Damage
6 Back Injuries
7 Animal Collisions
25
28%
TOP 5 MOST EXPENSIVE AND LEAST EXPENSIVE STATES FOR AUTOMOBILE INSURANCE...
RED CARS!
STOP
16%
THEFT
84%
FOR SALE
HALF
Average Loss Per Claim

INNER STATE
10
SIGNS YOU ARE TRULY HAPPY
1. Daily Exercise.
2. Happy Friends.
3. Smart thrills.
4. Enough Sleep.
ONE WAY
5. Self-trust.
DO NOT PASS
6. Live in the now.
7. Gratitude.
8. Bounce back.
9. Get Unplugged.
10. Smile.

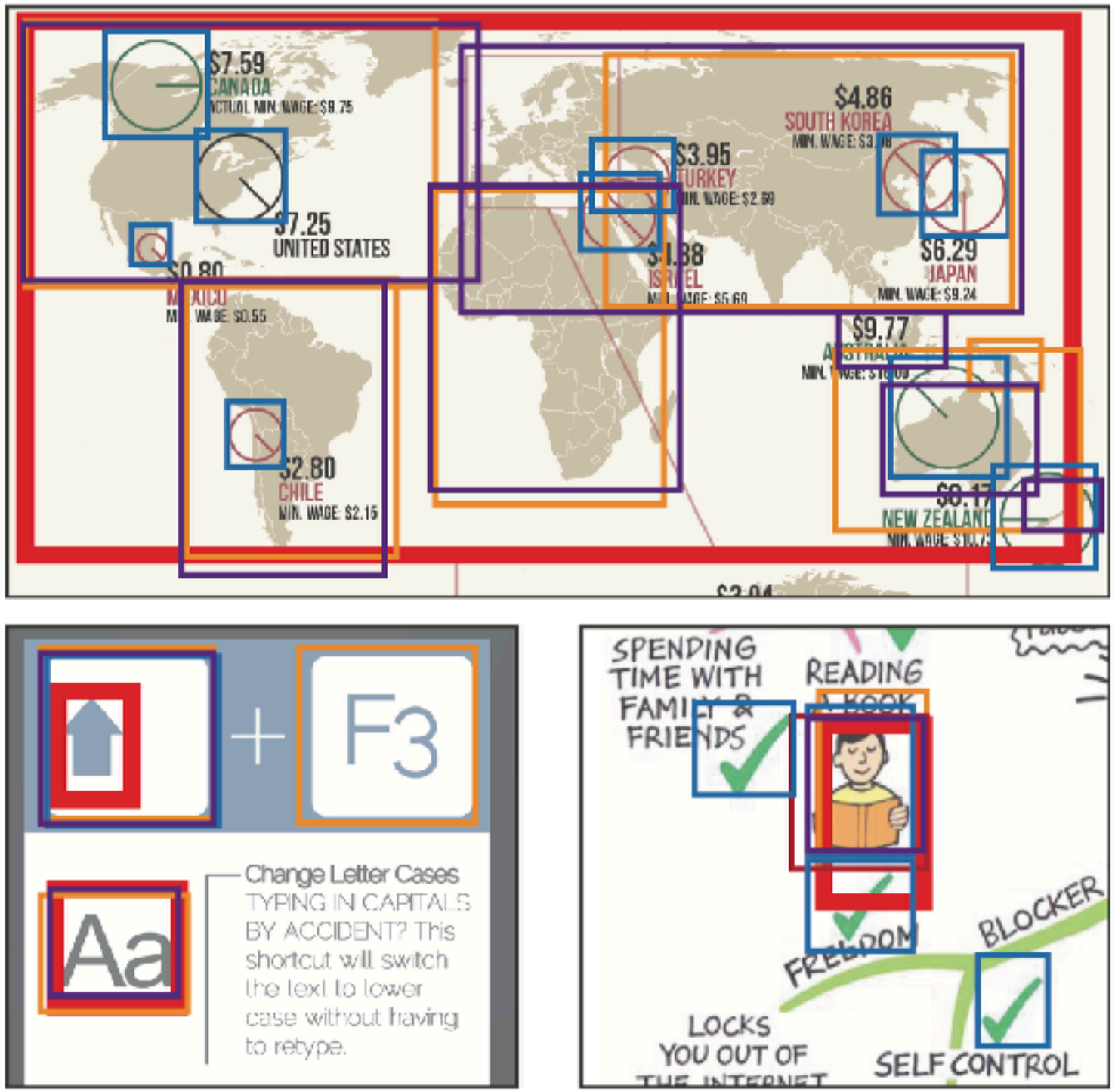
Switching bank accounts : would you take the plunge?
first direct
44%
BANK GLUE
27%
4%
6%
CHARGES
CHARGES
CHARGES
LOCAL BRANCH CLOSED
MY BANK IS RUBBISH

Evaluation

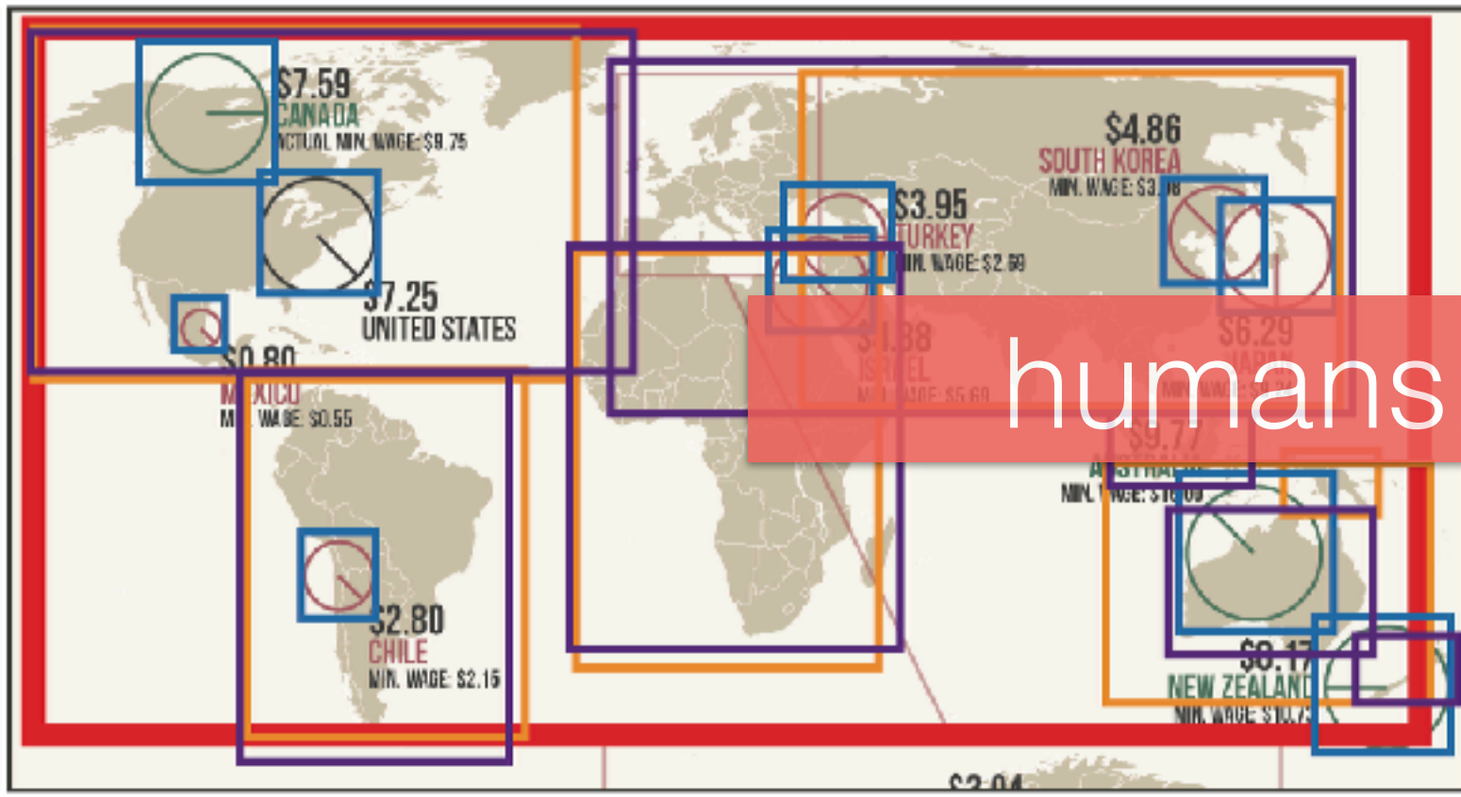

Label these images!
Instructions
Click and drag your mouse to mark ALL pictographs of the image that correspond to gaming.
Guidelines:
1. Click and drag your mouse to draw a box.
2. Draw bounding boxes around the visual features of this image that match the tag provided. You may draw multiple.
3. Do not box any text.
4. Press "Clear" to clear all boxes you've drawn so far.
5. Press "Submit" when you're satisfied with the regions you've drawn.
6. Press "No Matches" if there are no visual features in the image that match the tag.
Examples:
GOOD- mark pictographs in the image
HOW TO EAT CHOCOLATE
...GUILT-FREE ! ! !
BAD - do not mark text


PlayStation 4
Coming end of 2013
All new DUALSHOCK Controller
309,49 million PS consoles sold
Gran Turismo 5
Box regions indicating icon.
Clear
Submit
No Matches

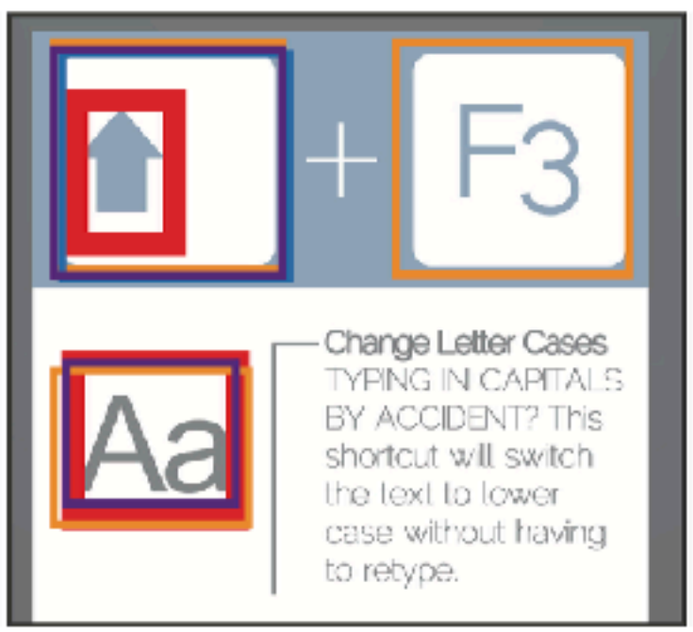
Evaluation

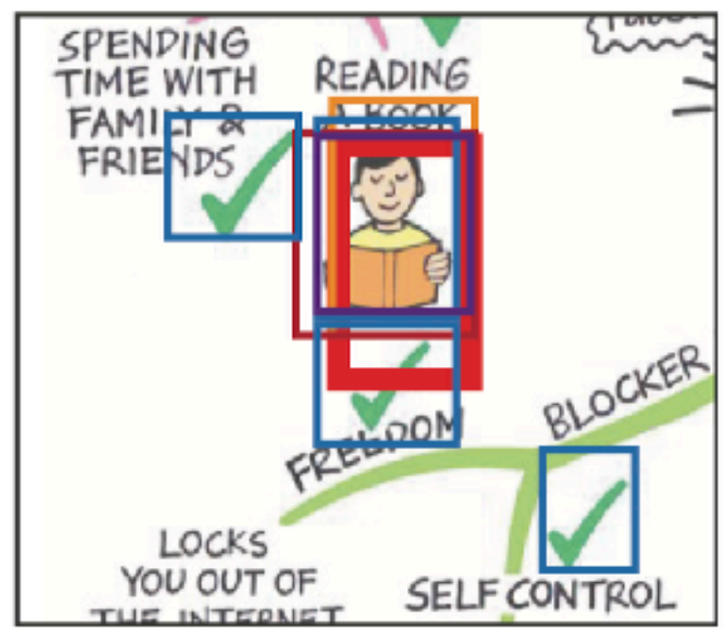

$7.59
CANADA
$7.25
UNITED STATES
$2.80
CHILE
MIN. WAGE: $2.15
$3.95
TURKEY
$4.86
SOUTH KOREA
$6.29
JAPAN
MIN. WAGE: $9.24
$9.77
NEW ZEALAND
F3
Aa
Change Letter Cases
TYPING IN CAPITALS BY ACCIDENT? This shortcut will switch the text to lower case without having to retype.
SPENDING TIME WITH
READING
FREEDOM
BLOCKER
LOCKS YOU OUT OF
SELF CONTROL

Evaluation

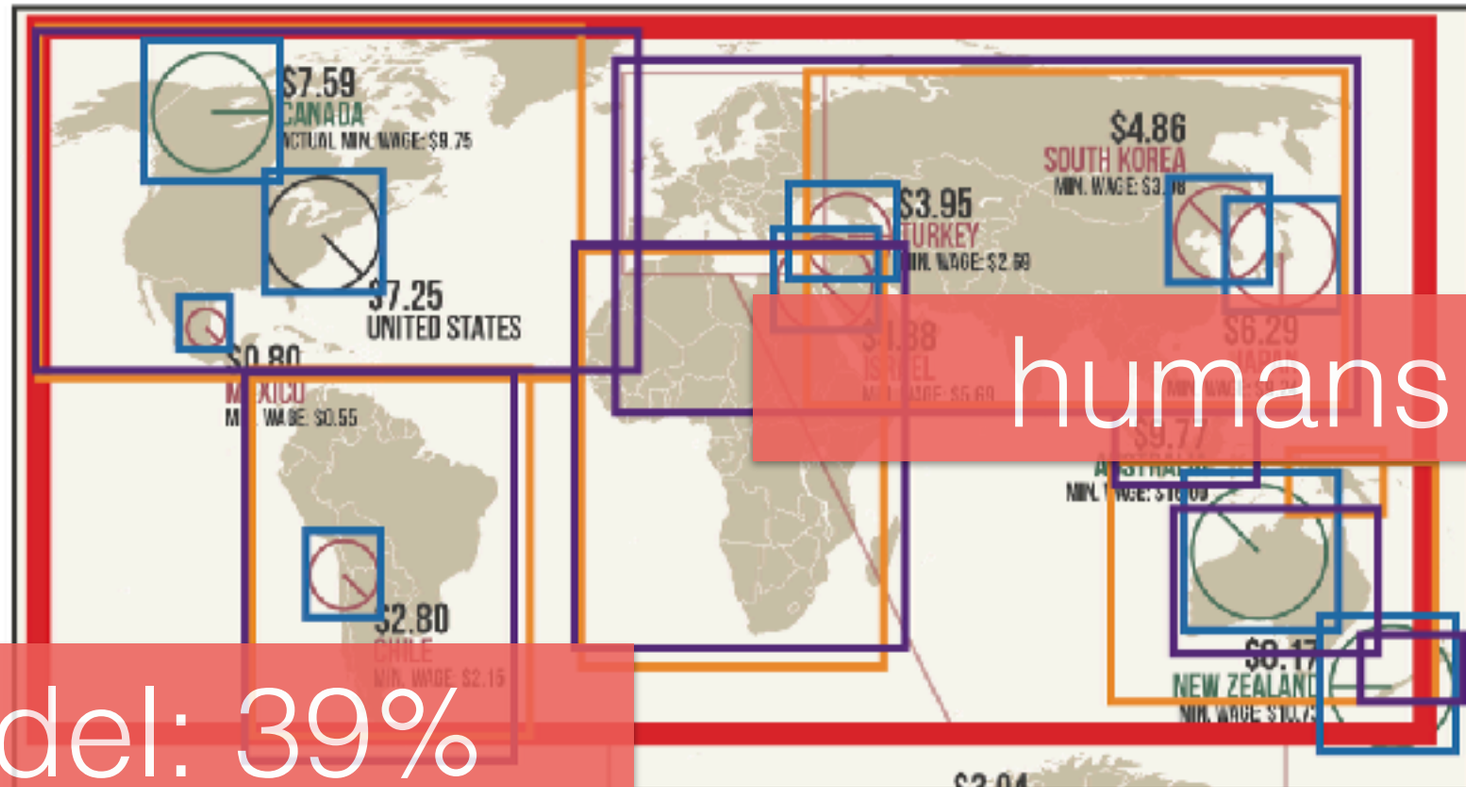


humans: 63%



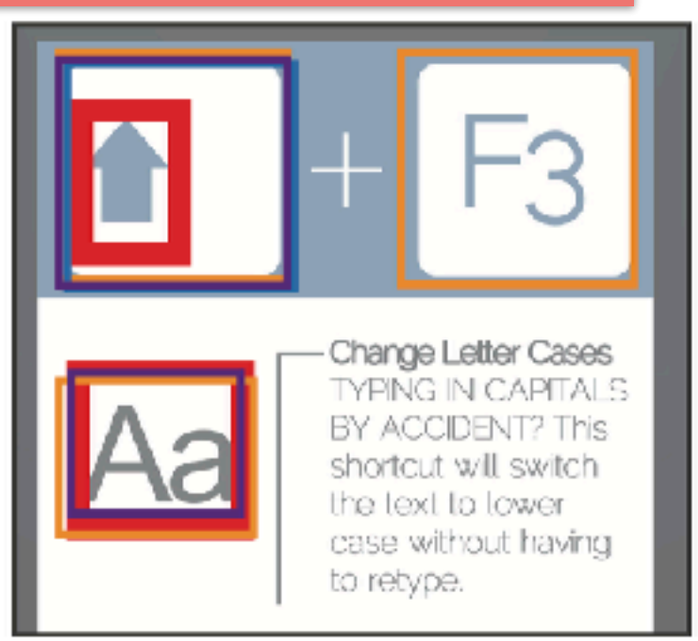


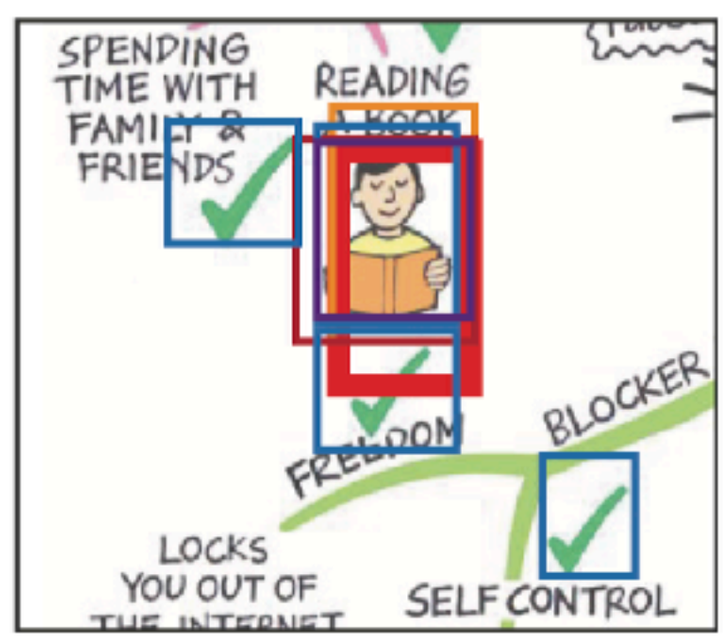
Evaluation



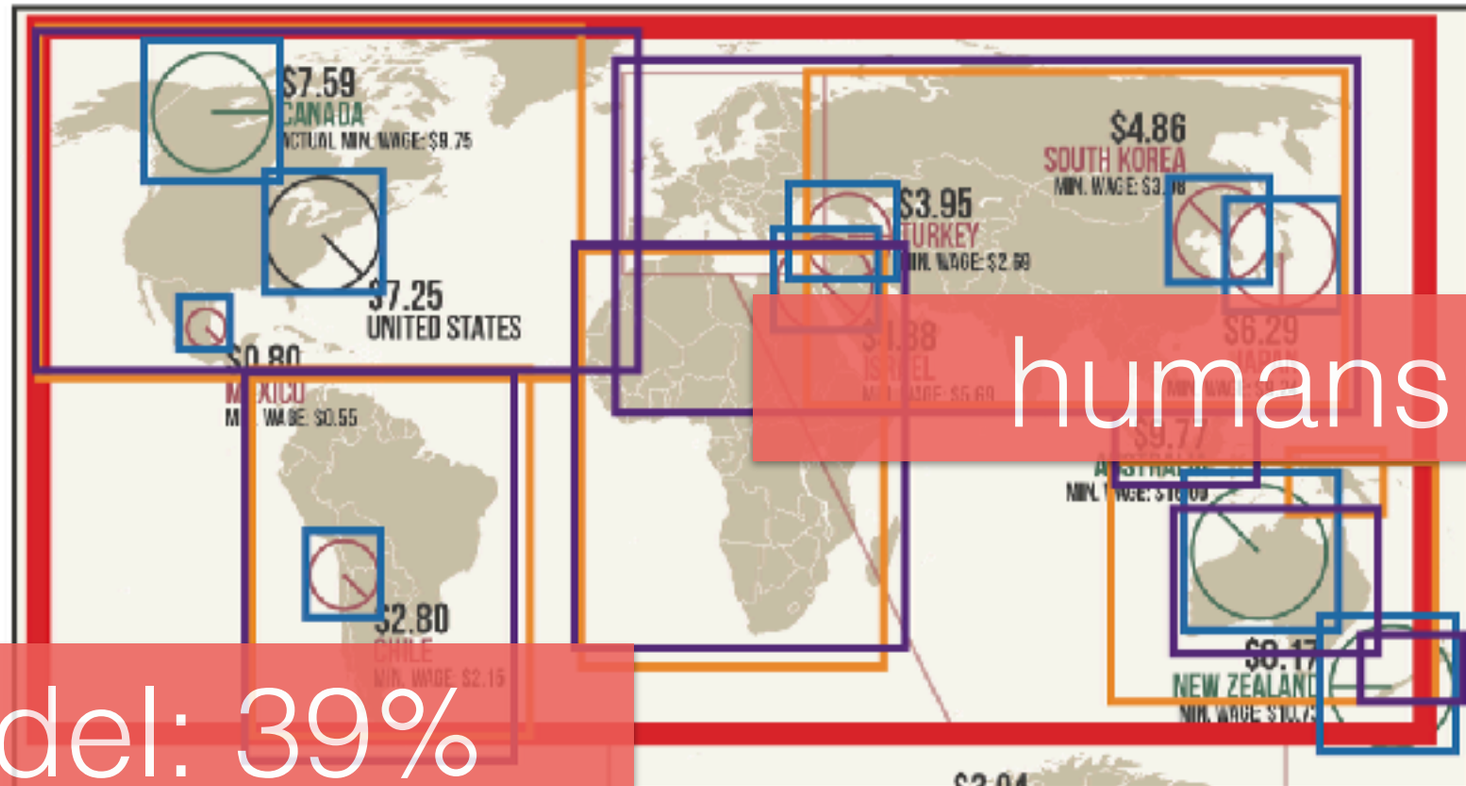
humans: 63%

our model: 39%



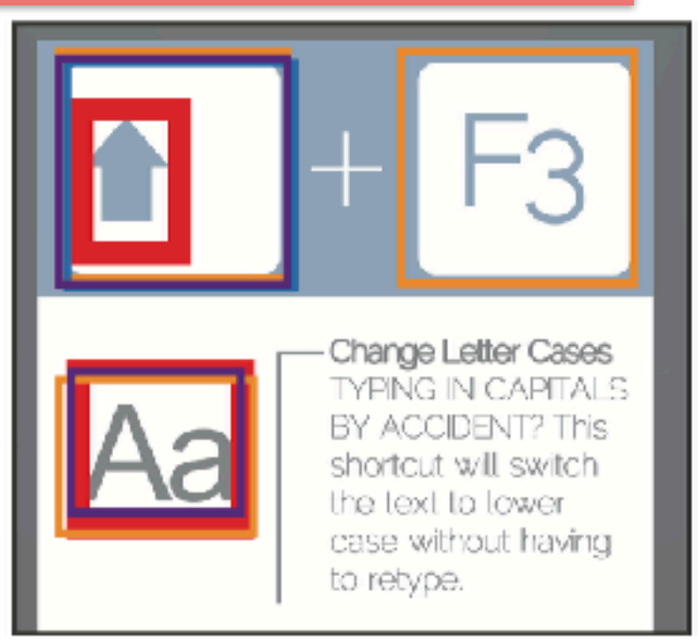


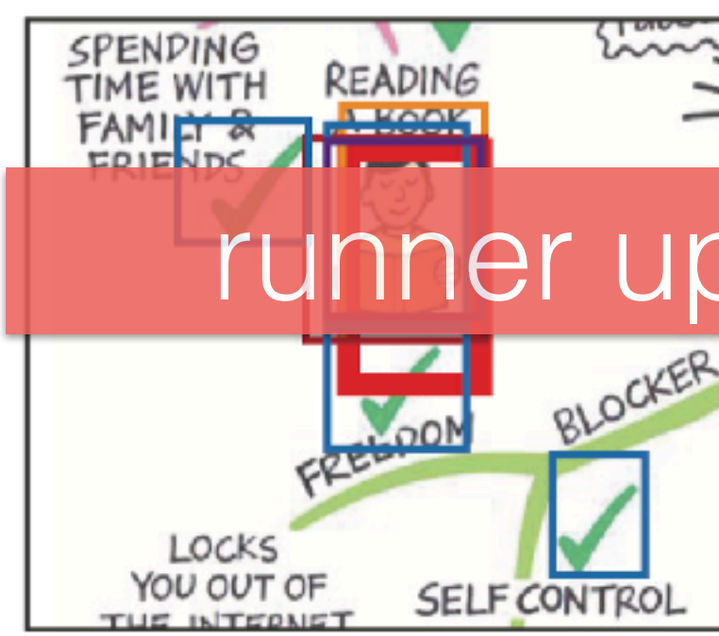
Evaluation



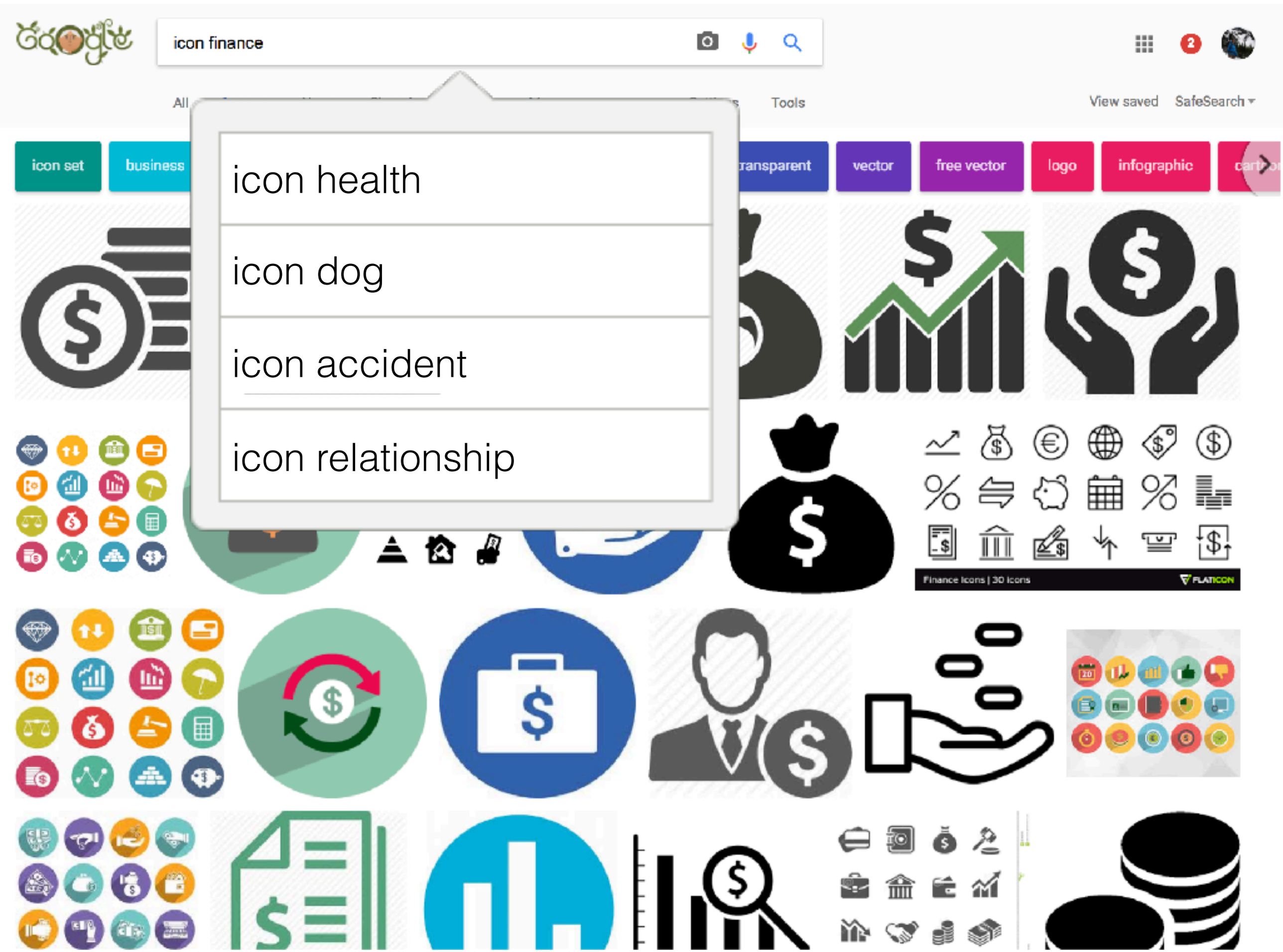
humans: 63%

our model: 39%





runner up: 14%


icon finance
All
Tools
View saved
SafeSearch
icon set
business
transparent
vector
free vector
logo
infographic
icon health
icon dog
icon accident
icon relationship
Finance Icons | 30 Icons
FLATICON

Icon classification

a)

#health
#medicine
#doctor

b)

#dog

c)

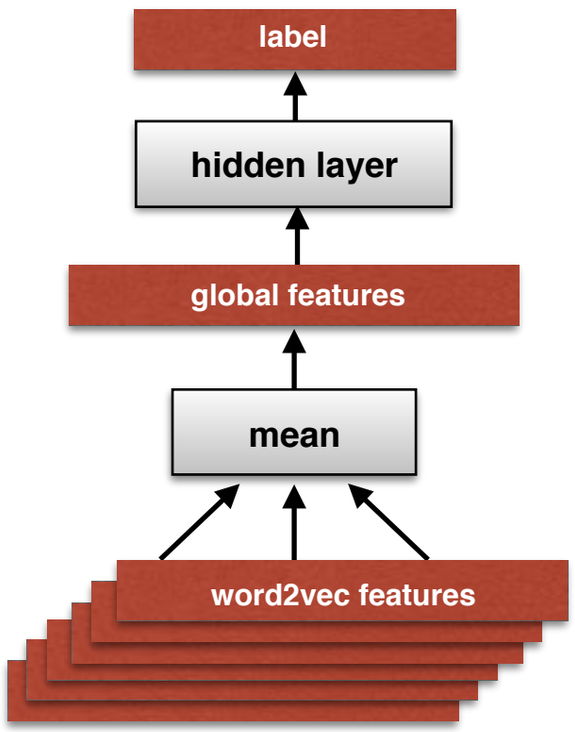
#accident

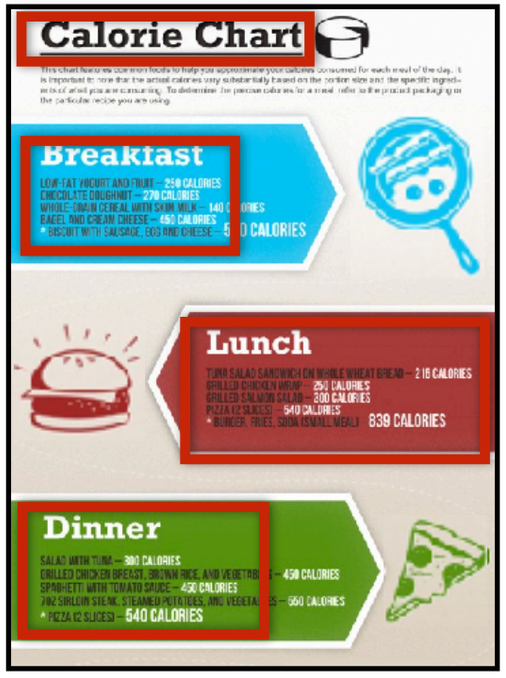
Icon classification

Icon detection & classification

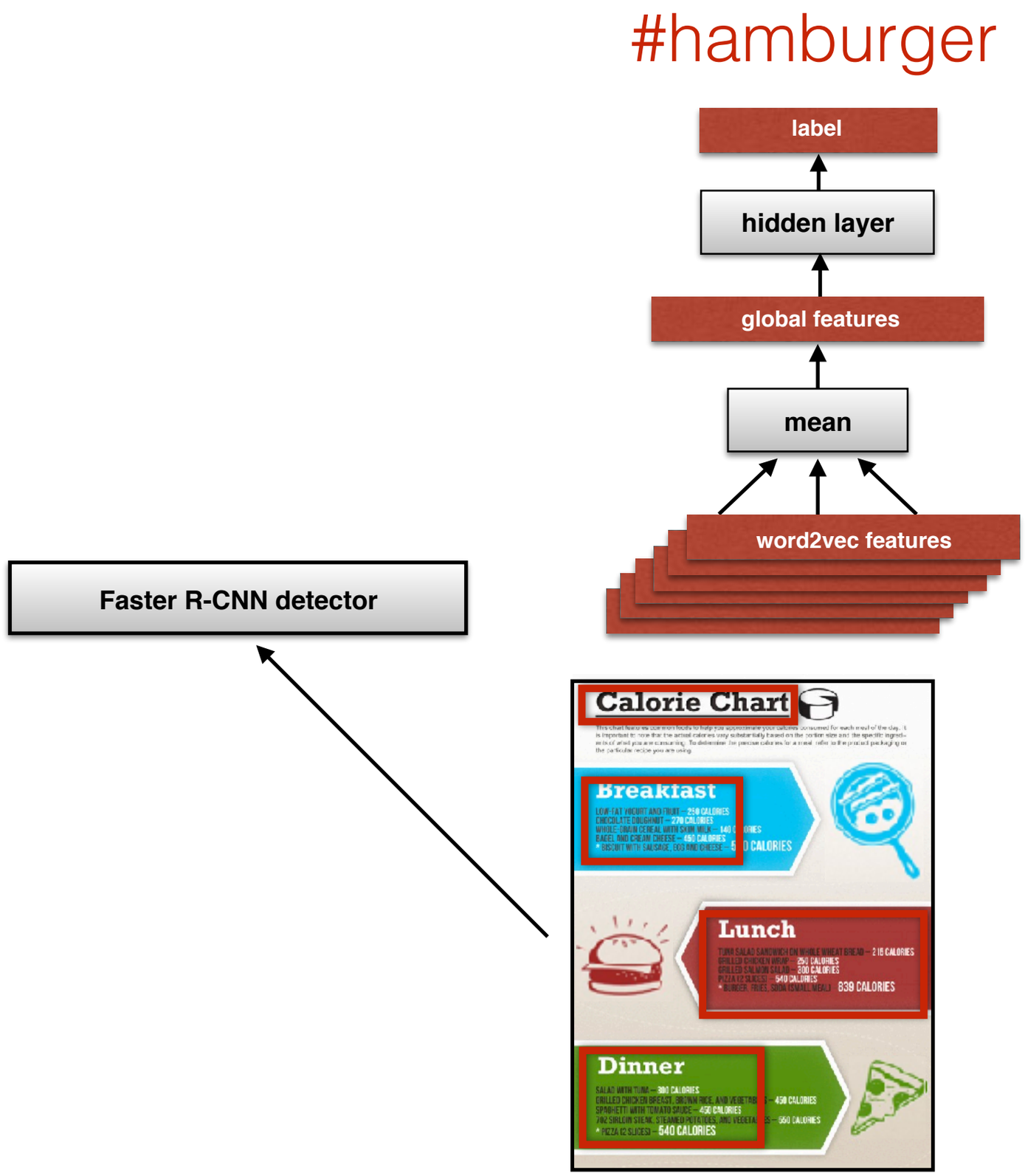
Bylinskii*, Madan*, Tancik* et al. [under review]

#hamburger

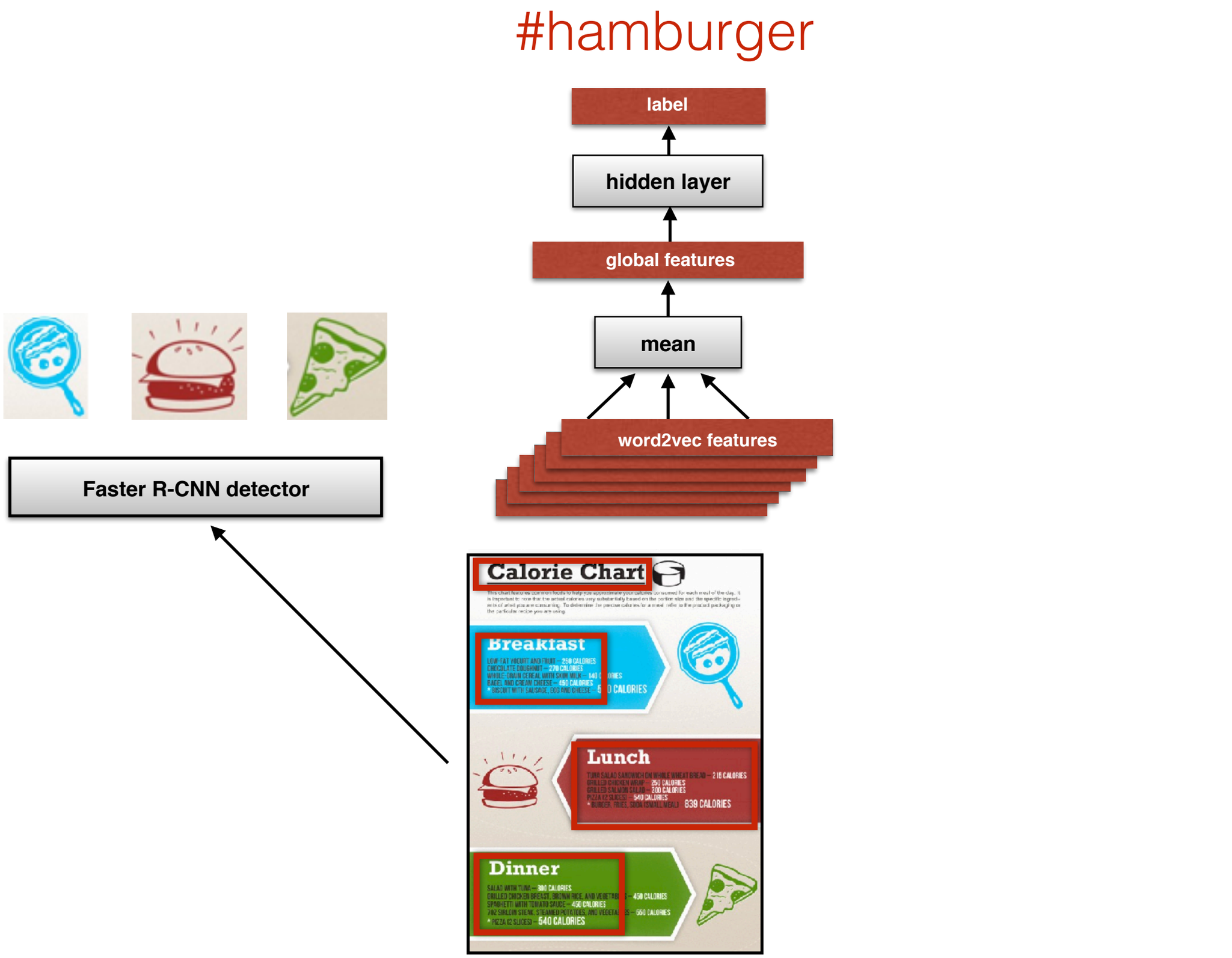




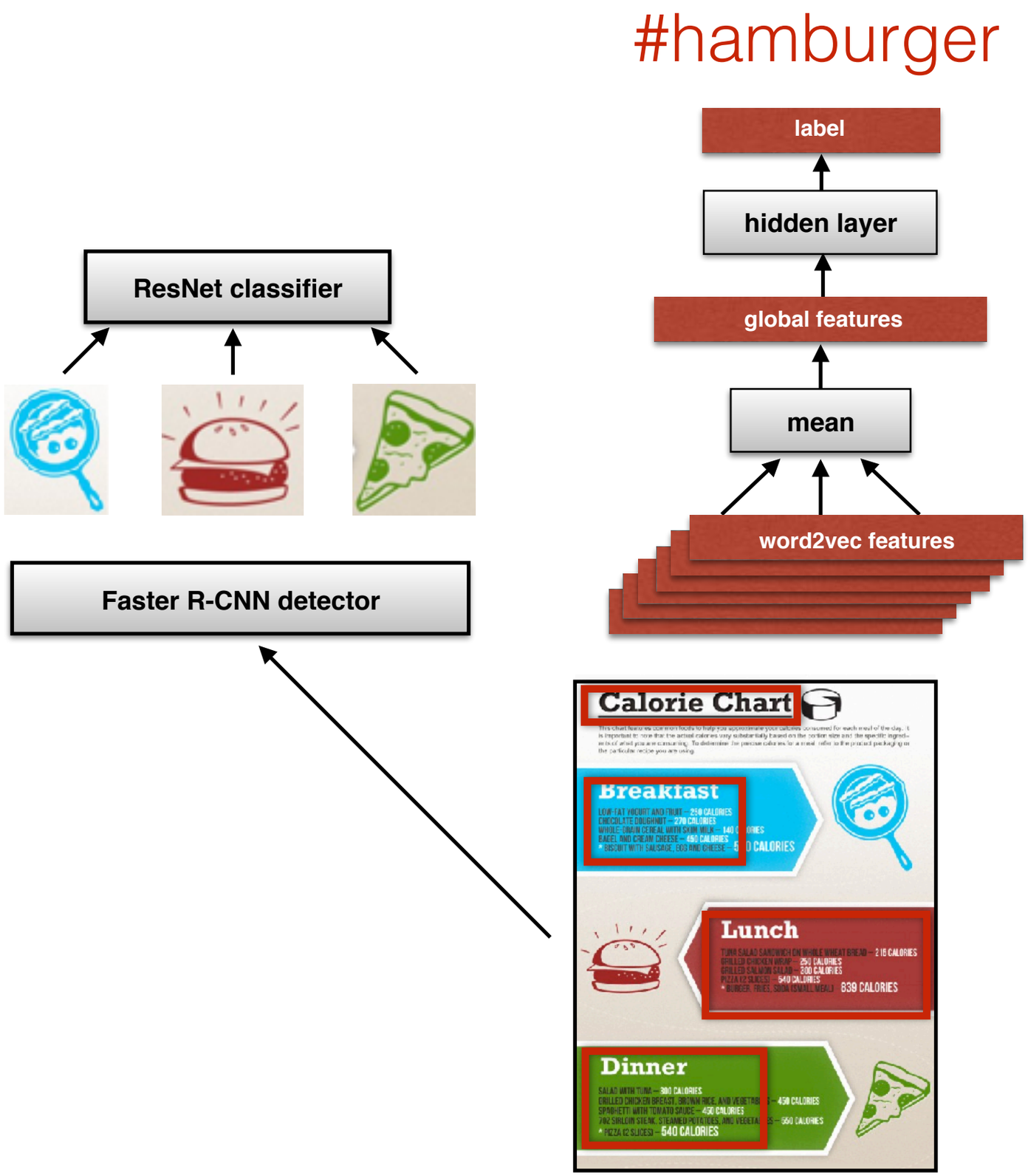
Bylinskii*, Madan*, Tancik* et al. [under review]



Bylinskii*, Madan*, Tancik* et al. [under review]

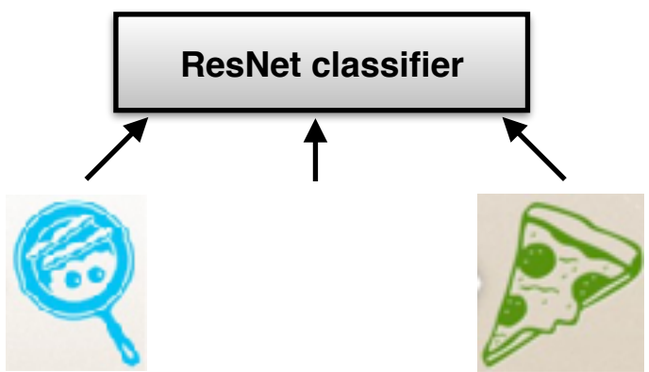


Bylinskii*, Madan*, Tancik* et al. [under review]



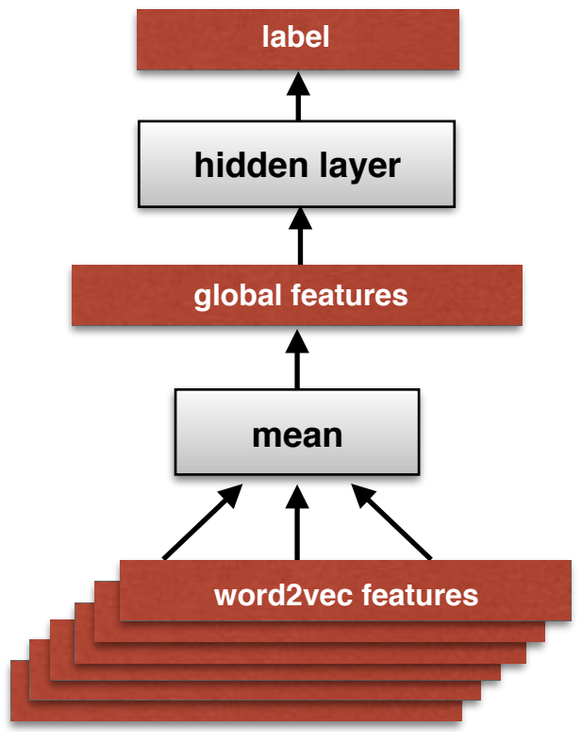
Bylinskii*, Madan*, Tancik* et al. [under review]

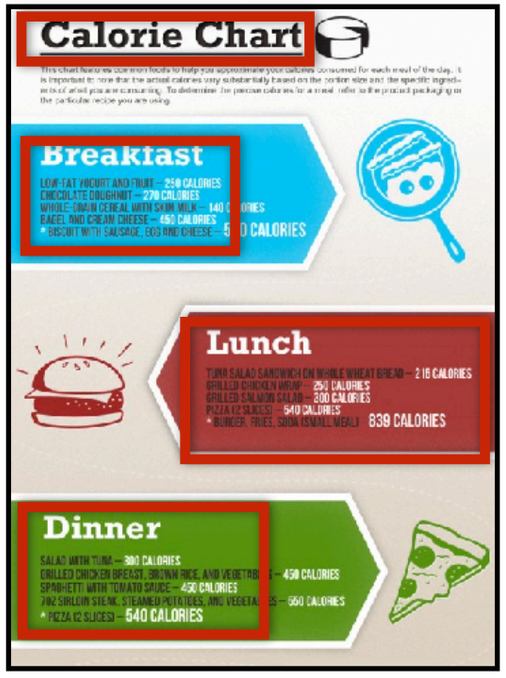
visual hashtag:



Faster R-CNN detector

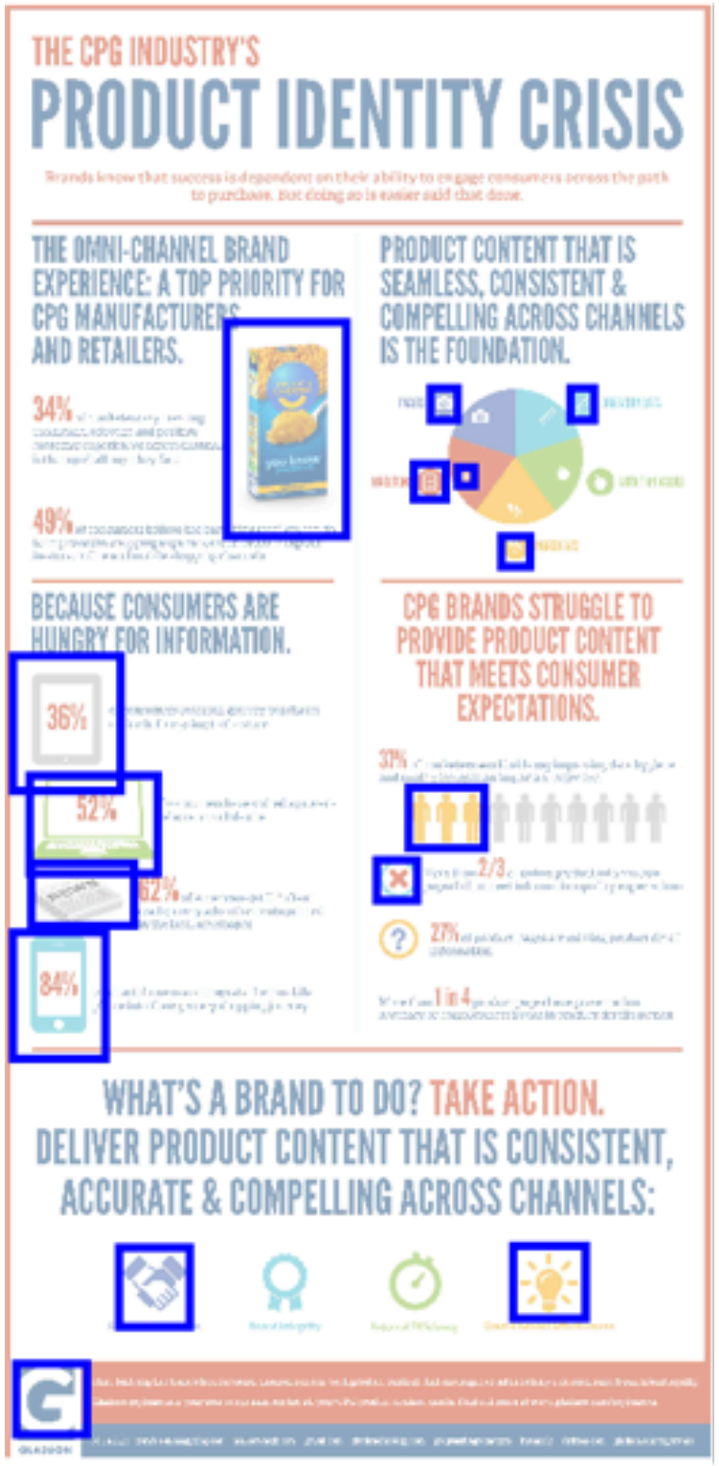
#hamburger





Bylinskii*, Madan*, Tancik* et al. [under review]

Visual #hashtags



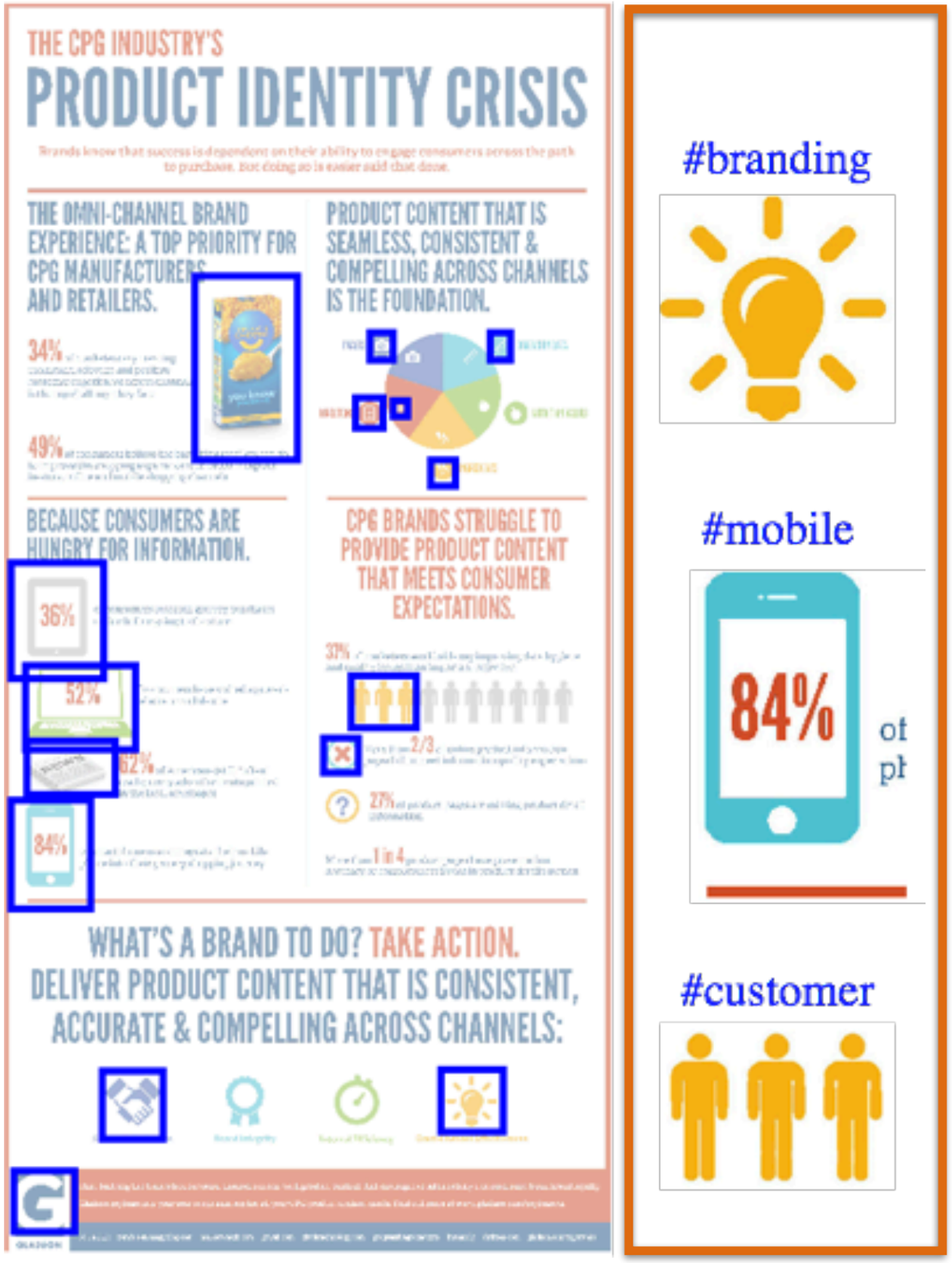
#branding

#mobile

#customer

Bylinskii*, Madan*, Tancik* et al. [under review]

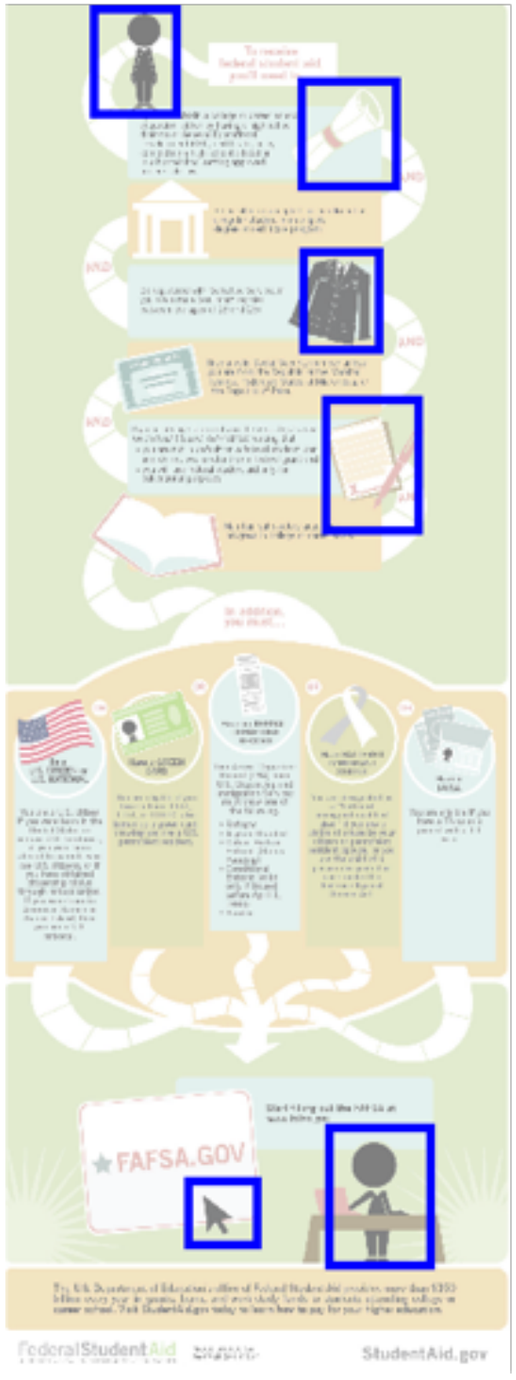
Visual #hashtags



multi-modal summary

Bylinskii*, Madan*, Tancik* et al. [under review]

Visual #hashtags



#education

#tax

#student

#application

#social media

#cell phone

Bylinskii*, Madan*, Tancik* et al. [under review]

Dense annotation

Bylinskii*, Madan*, Tancik* et al. [under review]

reduce
REUSE
recycle

Cut down on what you throw away. Follow the three "R's" to conserve natural resources and landfill space.

choose sustainable

Learn how to make smart seafood choices at www.FishWatch.gov.

Trees provide food and oxygen. They help save energy, clean the air, and help combat climate change.

PLANT A TREE

BIKE MORE
DRIVE LESS

PROTECTING OUR PLANET STARTS WITH YOU

seafood

EDUCATE

-SHOP-
WISELY

When you further your own education, you can help others understand the importance and value of our natural resources.

Volunteer for cleanups in your community. You can get involved in protecting your watershed too!

The less water you use, the less runoff and wastewater that eventually end up in the ocean.

Buy less plastic and bring a reusable shopping bag.

CONSERVE WATER

Long-lasting light bulbs

- ARE A -
BRIGHT IDEA

Energy efficient light bulbs reduce greenhouse gas emissions. Also flip the light switch off when you leave the room!

oceanservice.noaa.gov

Don't send chemicals into our waterways.

Choose nontoxic chemicals in the home and office.

choose sustainable

Learn how to make smart seafood choices at www.FishWatch.gov.

Cut down on what you throw away. Follow the three "R's" to conserve natural resources and landfill space.

Trees provide food and oxygen. They help save energy, clean the air, and help combat climate change.

seafood

EDUCATE

PROTECTING OUR PLANET STARTS WITH YOU

BIKE MORE
DRIVE LESS

reduce
REUSE
recycle

CONSERVE
WATER

Don't send chemicals into our waterways.

Long-lasting light bulbs

PLANT
A TREE

-SHOP-
WISELY

When you further your own education, you can help others understand the importance and value of our natural resources.

Volunteer for cleanups in your community. You can get involved in protecting your watershed too!

The less water you use, the less runoff and wastewater that eventually end up in the ocean.

Buy less plastic and bring a reusable shopping bag.

oceanservice.noaa.gov

- ARE A -
BRIGHT
IDEA

Energy efficient light bulbs reduce greenhouse gas emissions. Also flip the light switch off when you leave the room!

Choose nontoxic chemicals in the home and office.

PROTECTING OUR PLANET STARTS WITH YOU
BIKE MORE
DRIVE LESS
EDUCATE
Volunteer!
reduce
REUSE
recycle
CONSERVE WATER
choose sustainable
SEAFOOD
SHOP
WISELY
LIGHT
BRIGHT
IDEA
PLANT
A TREE
Don't send chemicals into our waterways.

Multi-modal understanding

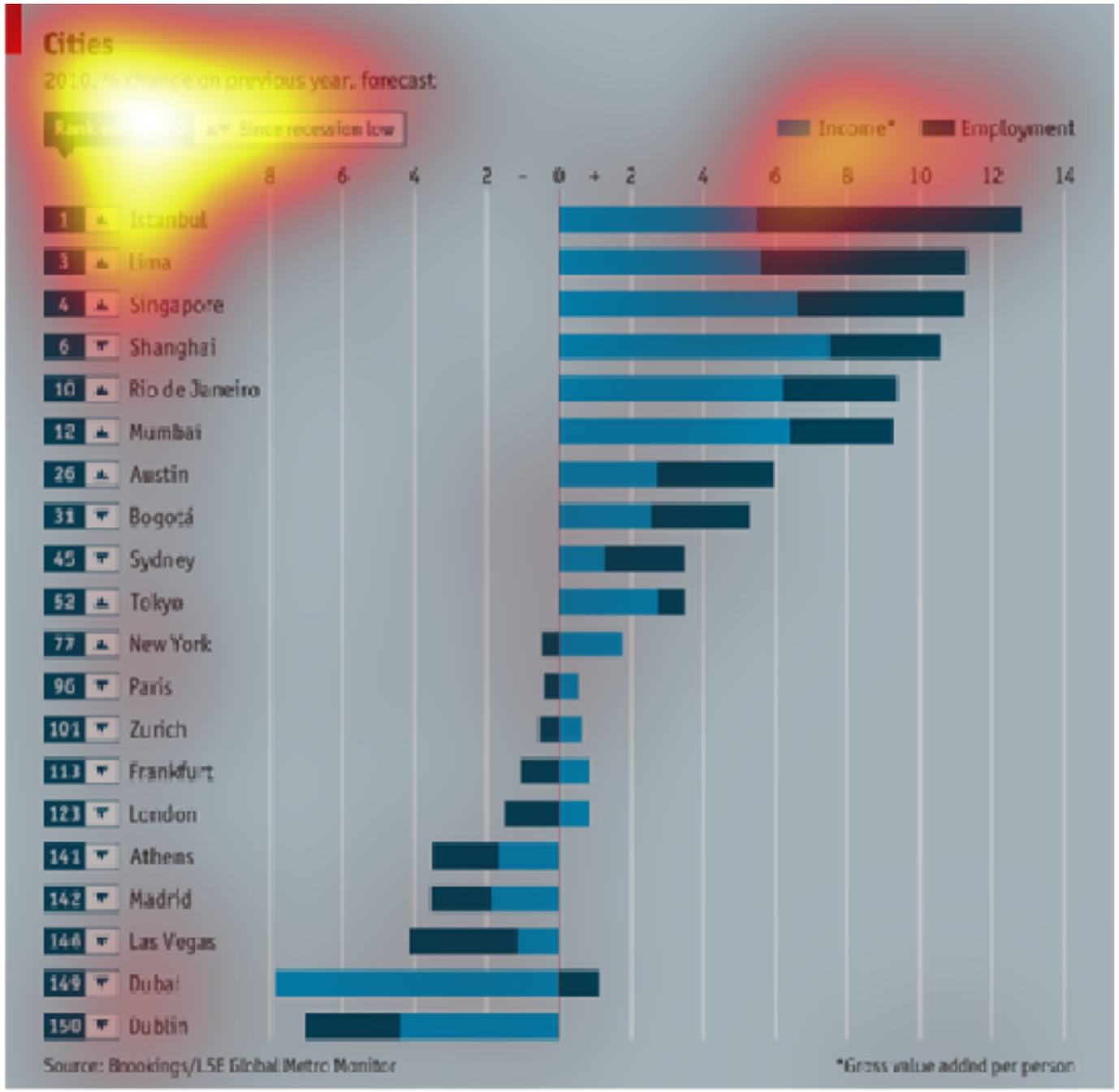
Topic prediction

Dense annotation

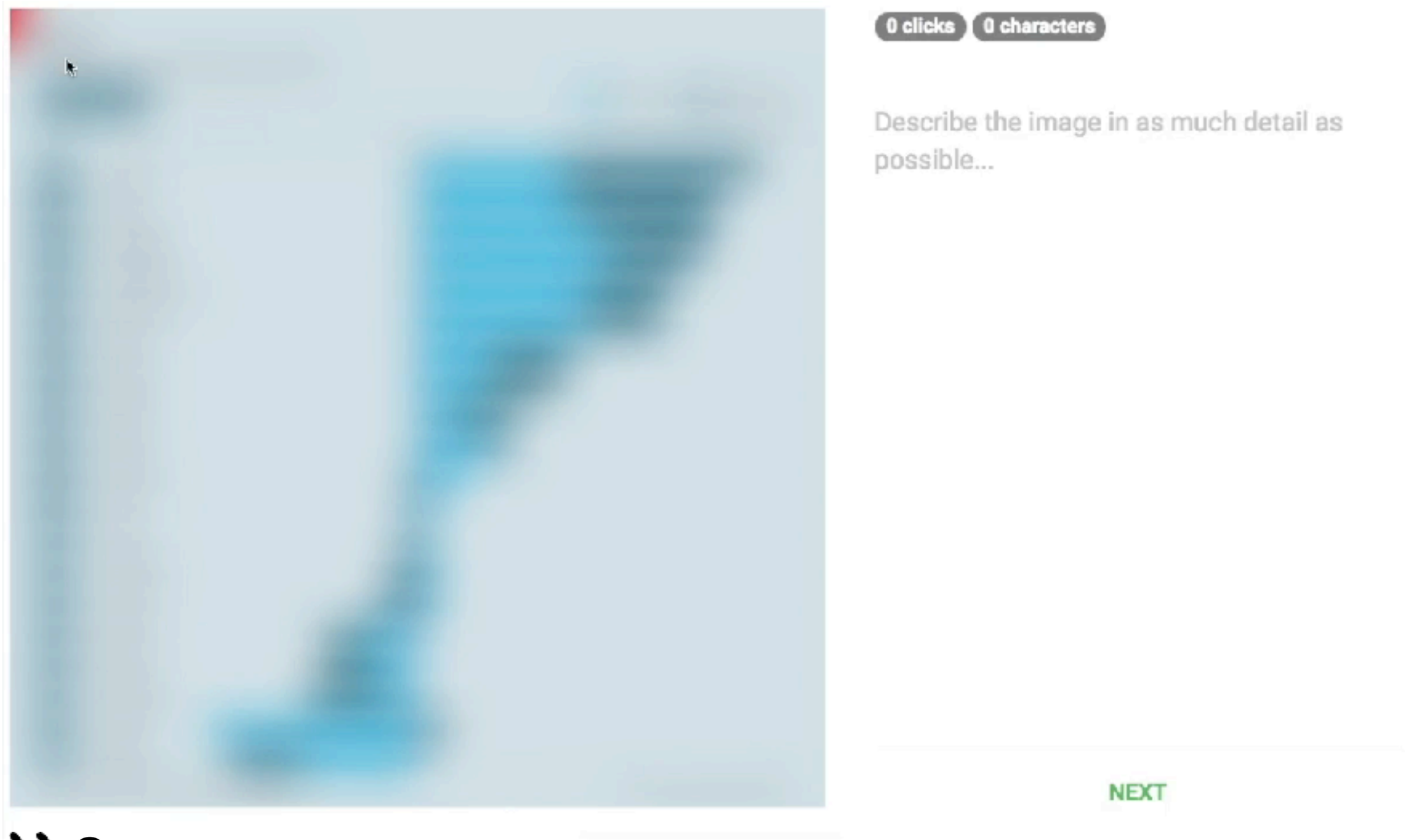
Attention Modeling

Summarization & Redesign

Capturing observer attention



Capturing observer attention

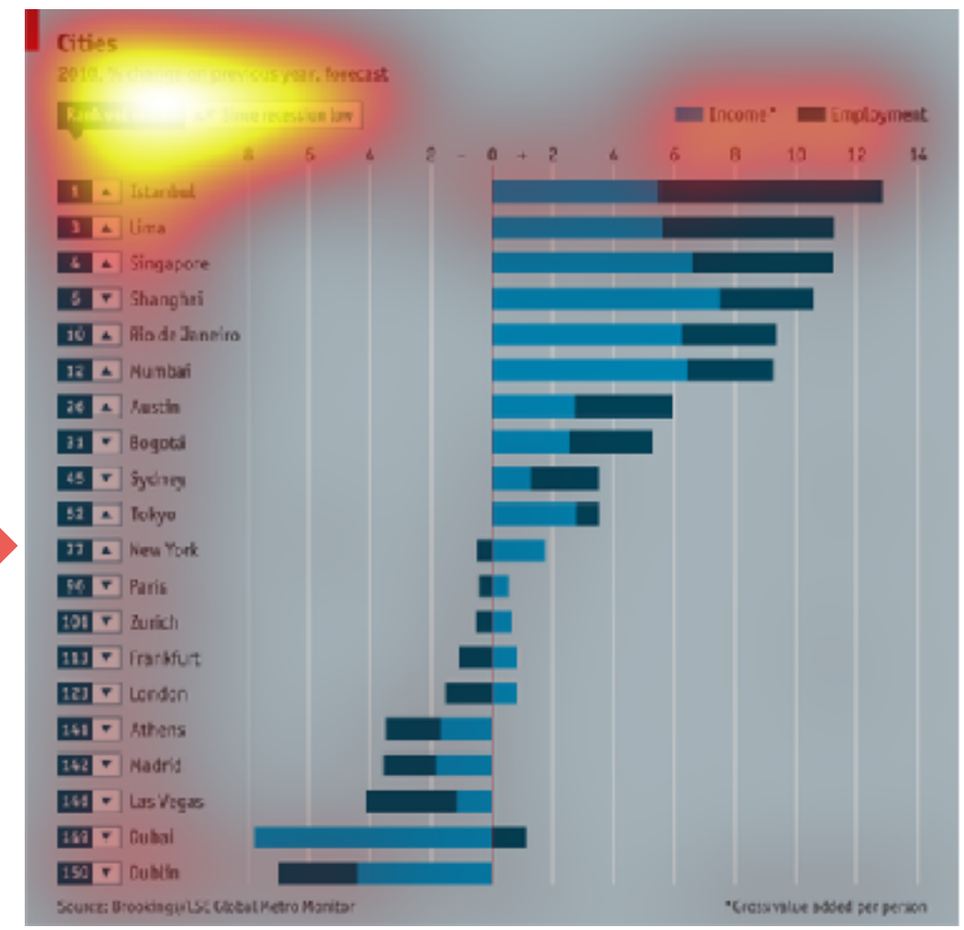


»2x

Kim*, Bylinskii*, et al. [TOCHI 2017]

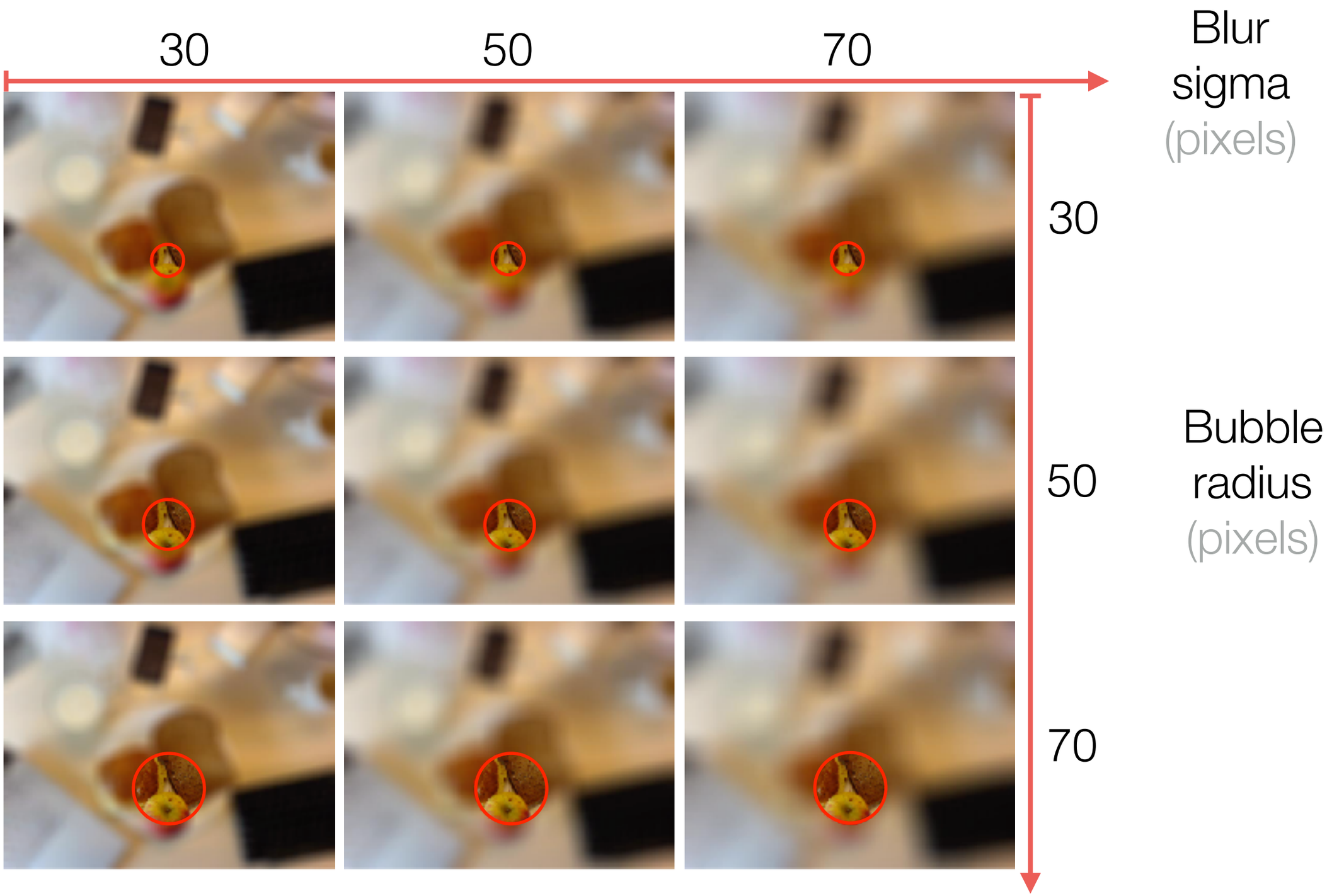
Capturing observer attention

Importance map



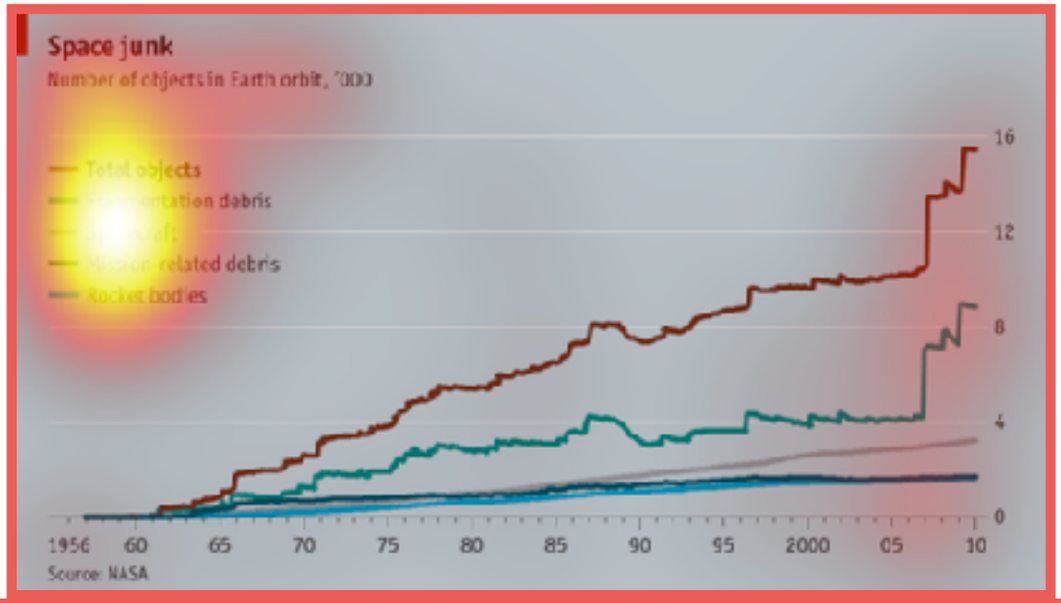
Kim*, Bylinskii*, et al. [TOCHI 2017]

Capturing observer attention

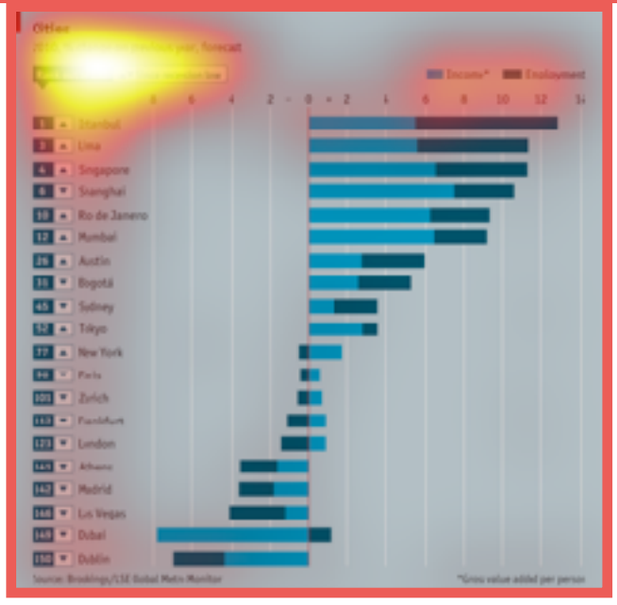


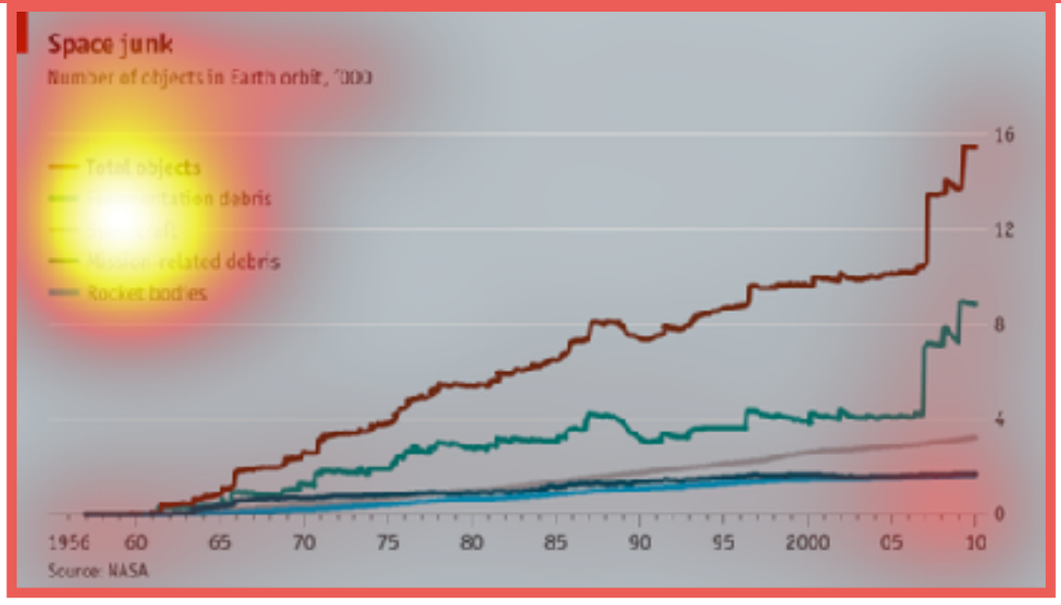
Kim*, Bylinskii*, et al. [TOCHI 2017]

Clicks approximate fixations



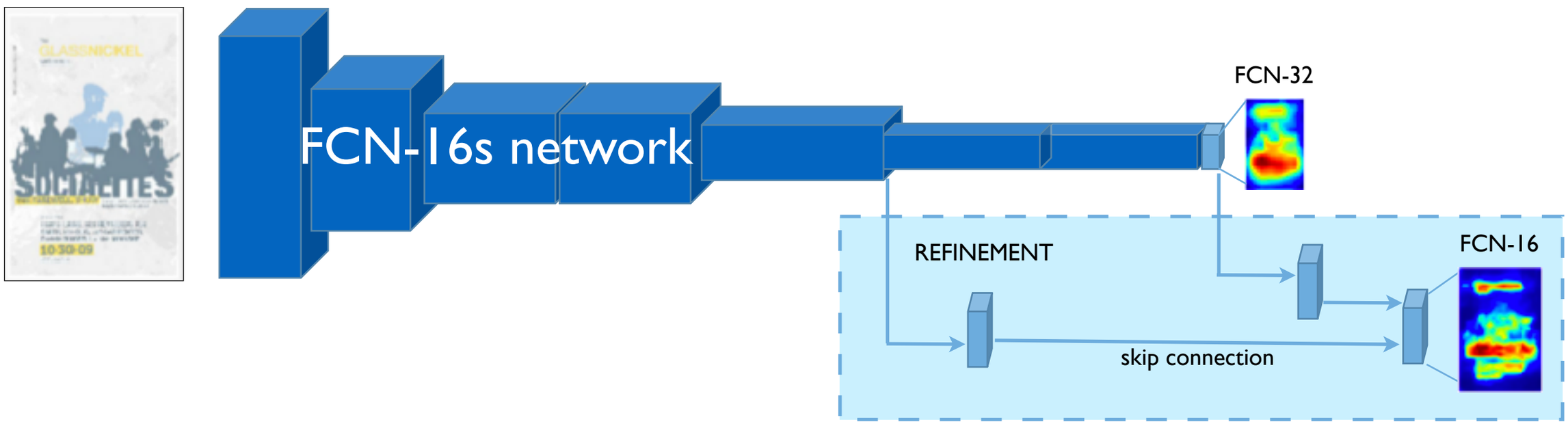
clicks of 10 participants explain 90% of fixations





Kim*, Bylinskii*, et al. [TOCHI 2017]

Predicting importance maps

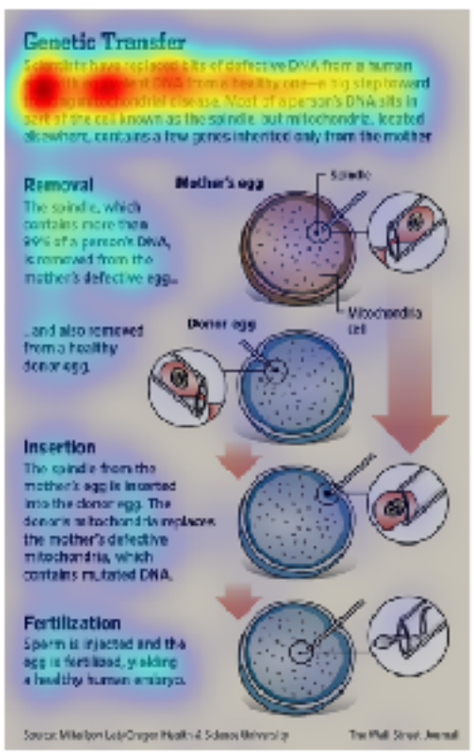


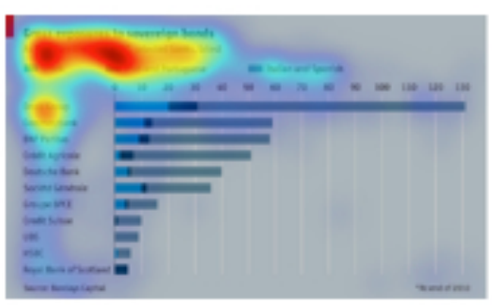
Bylinskii et al. [UIST 2017]

Predicting importance maps

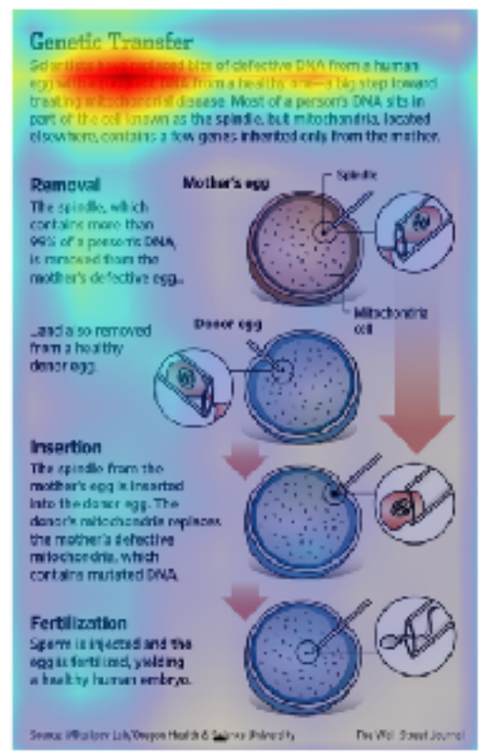
Data visualizations

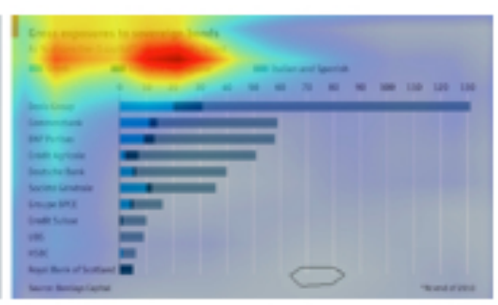
Ground truth





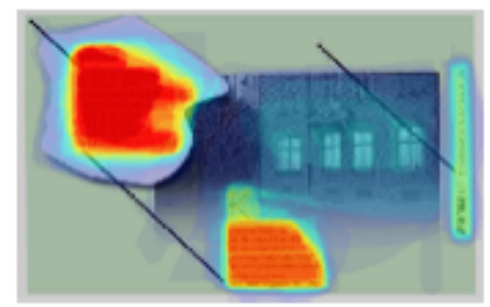
Prediction

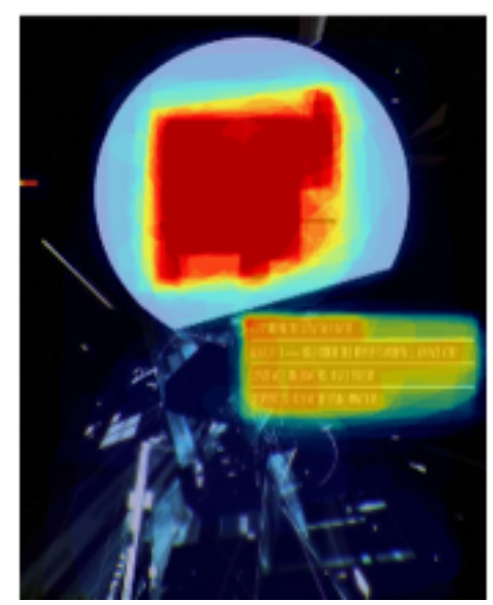




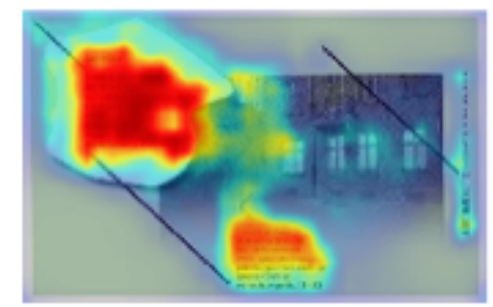
Graphic designs

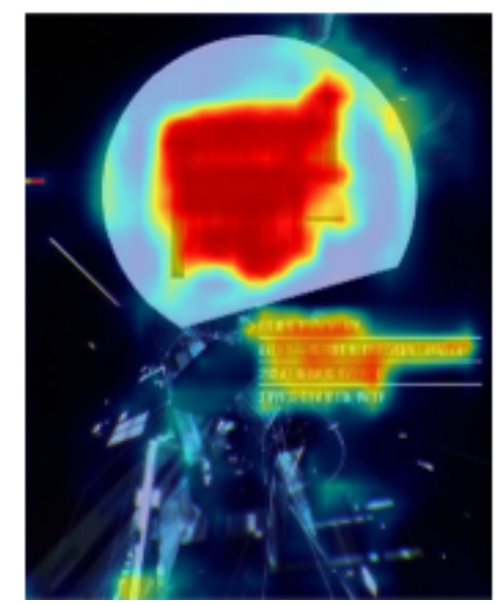
Ground truth





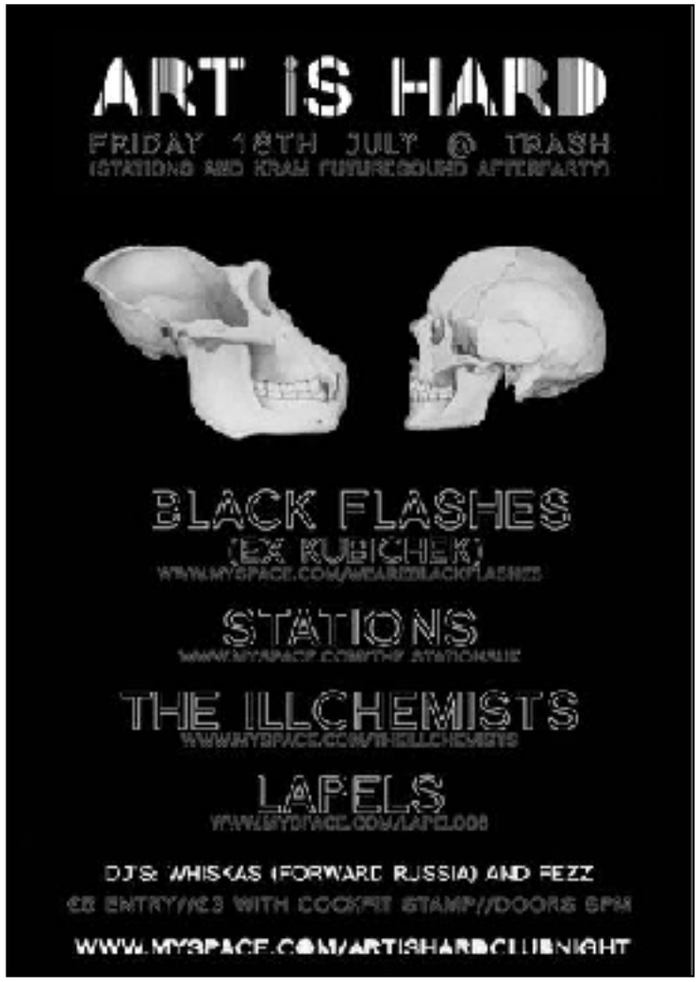
Prediction





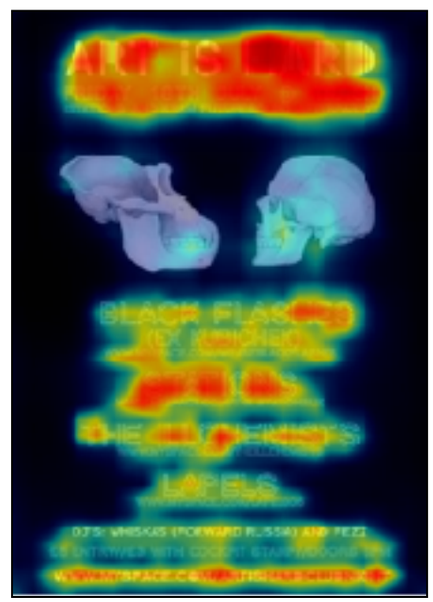
Bylinskii et al. [UIST 2017]

Retargeting



Original design

Importance heatmap



Our model

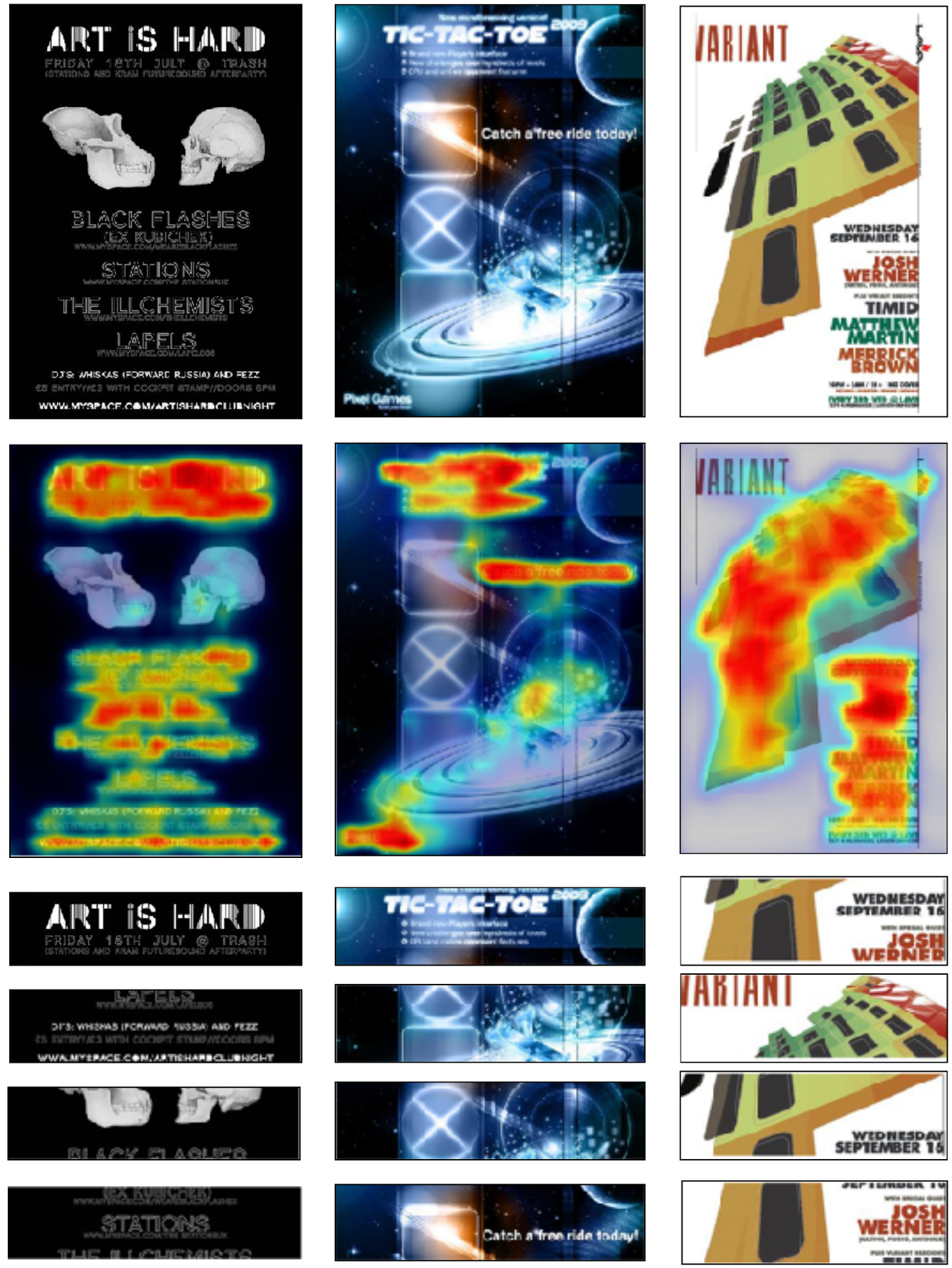
Model comparisons

Original design

Importance heatmap

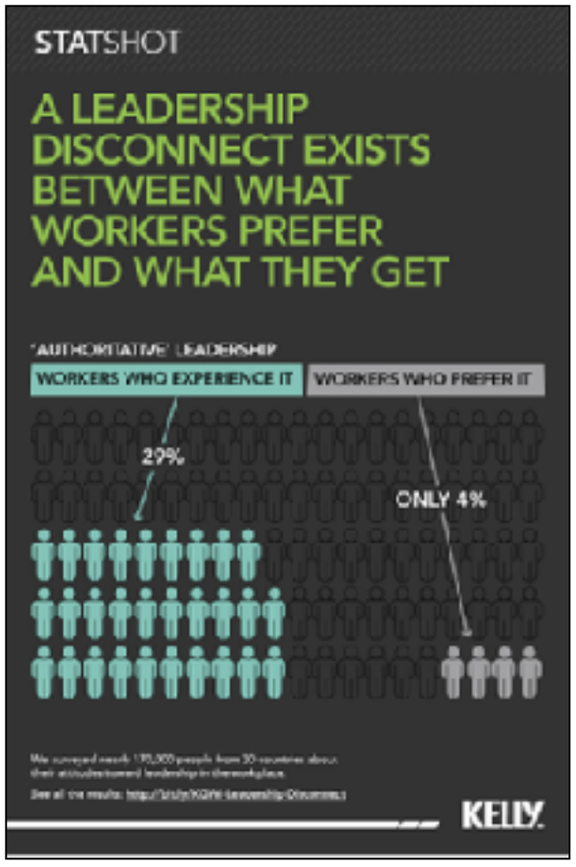
Our model

Model comparisons

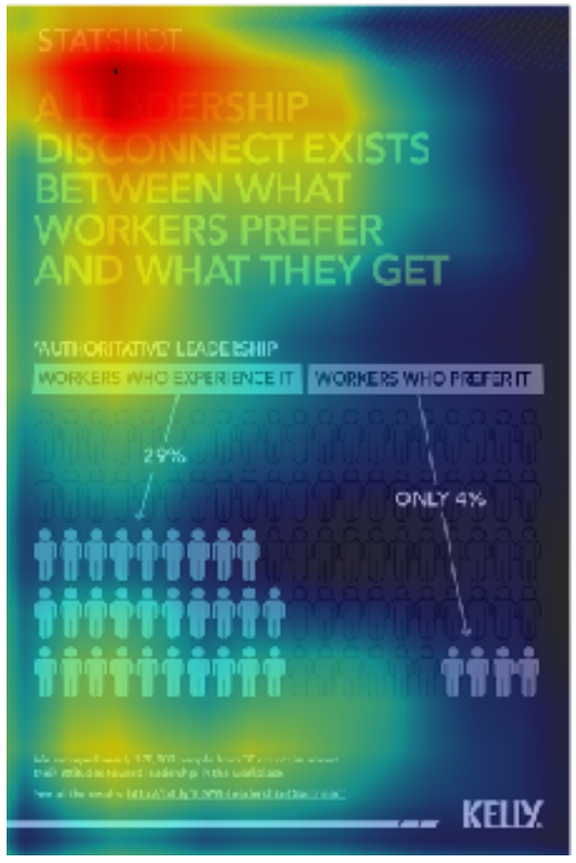


Thumbnailing

Input



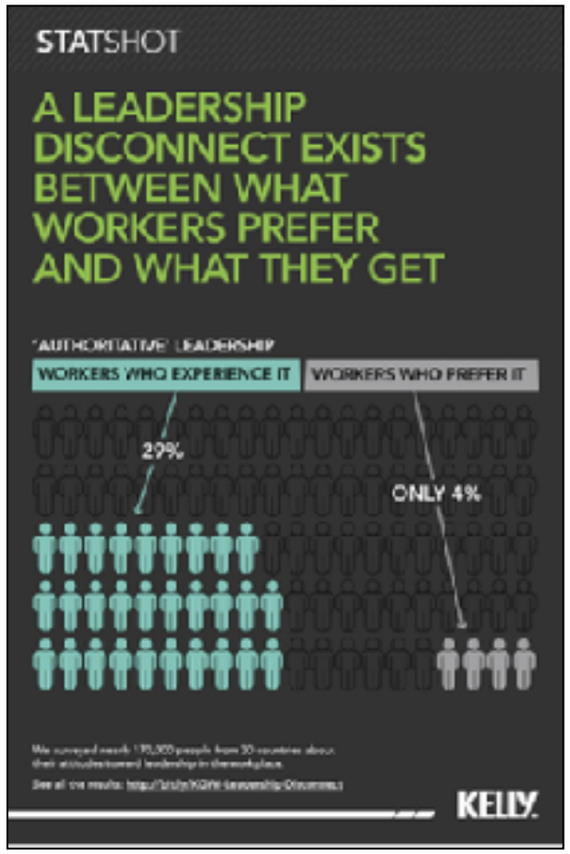
Importance heatmap

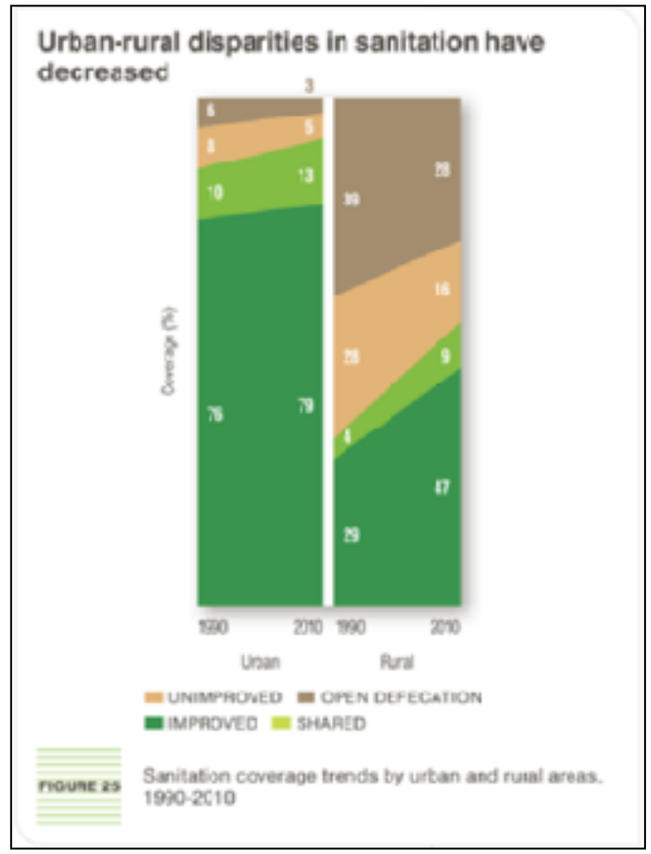


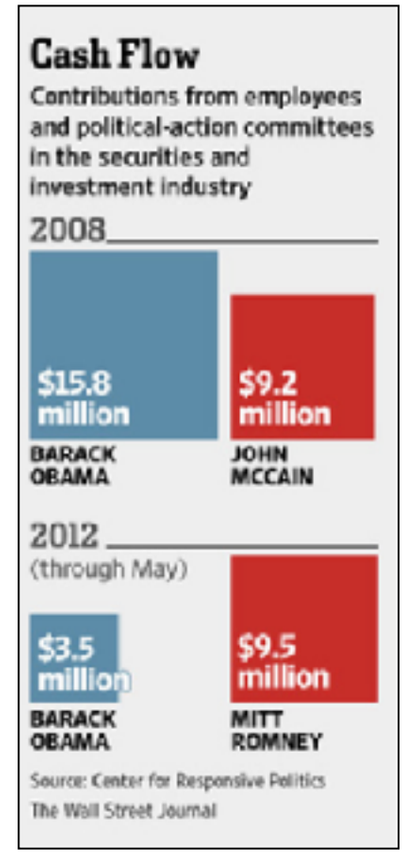
Thumbnail

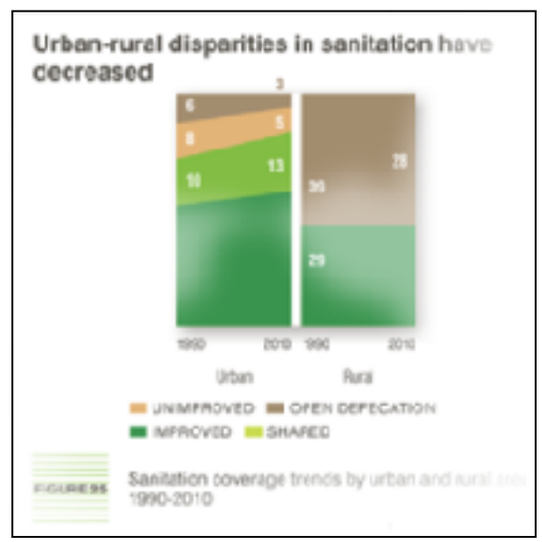
Bylinskii et al. [UIST 2017]

Thumbnailing



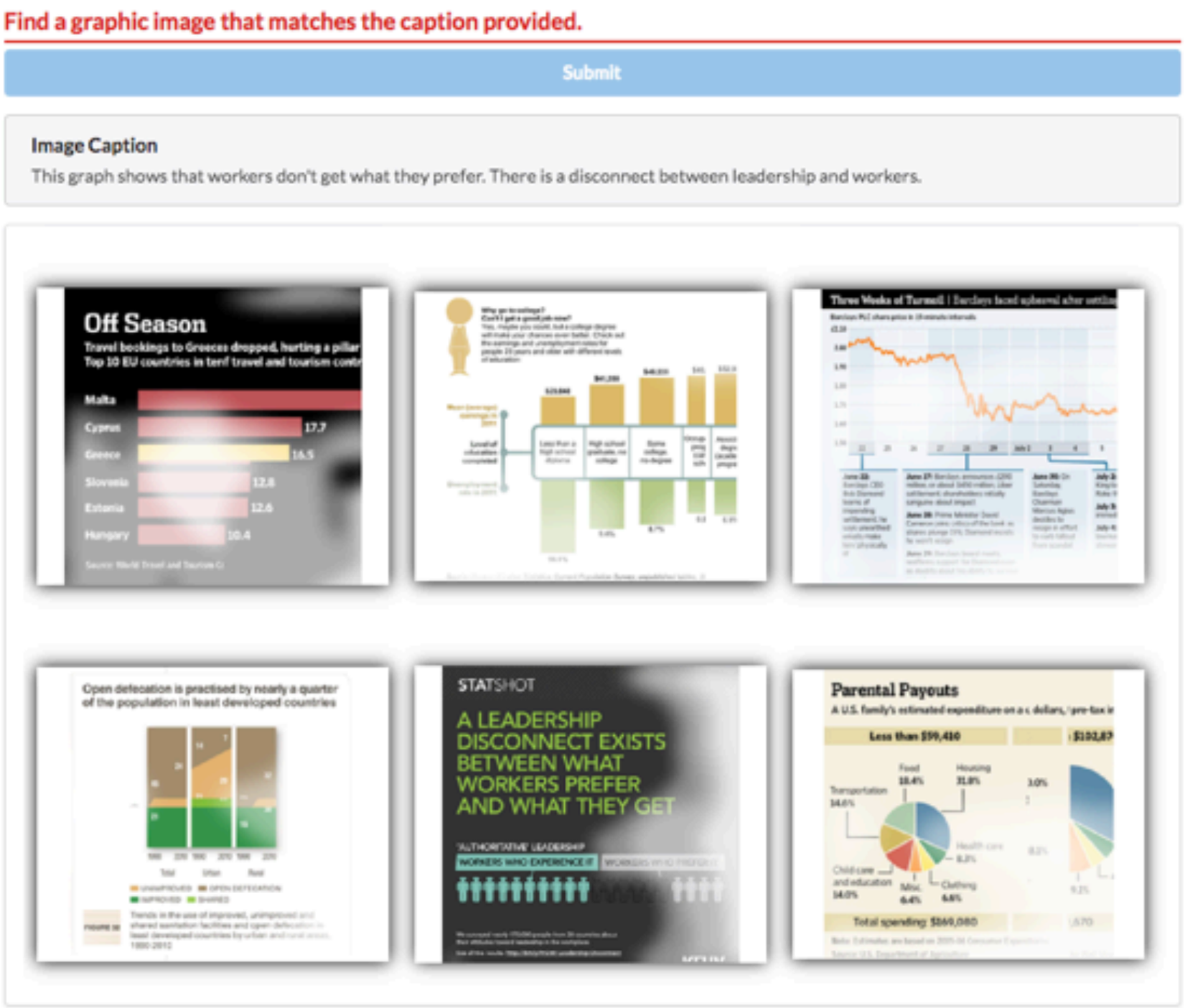






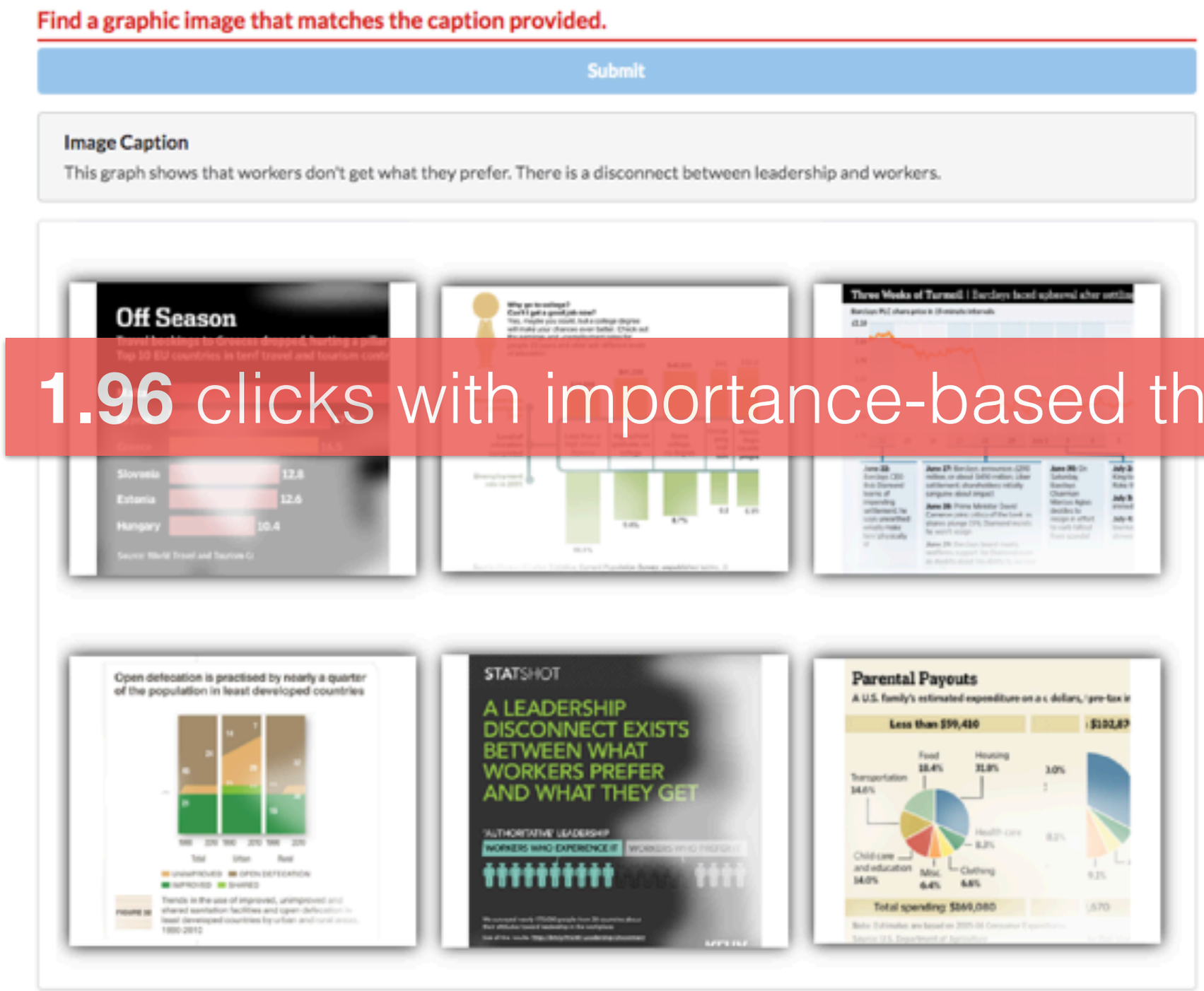
Bylinskii et al. [UIST 2017]

User evaluation



Bylinskii et al. [UIST 2017]

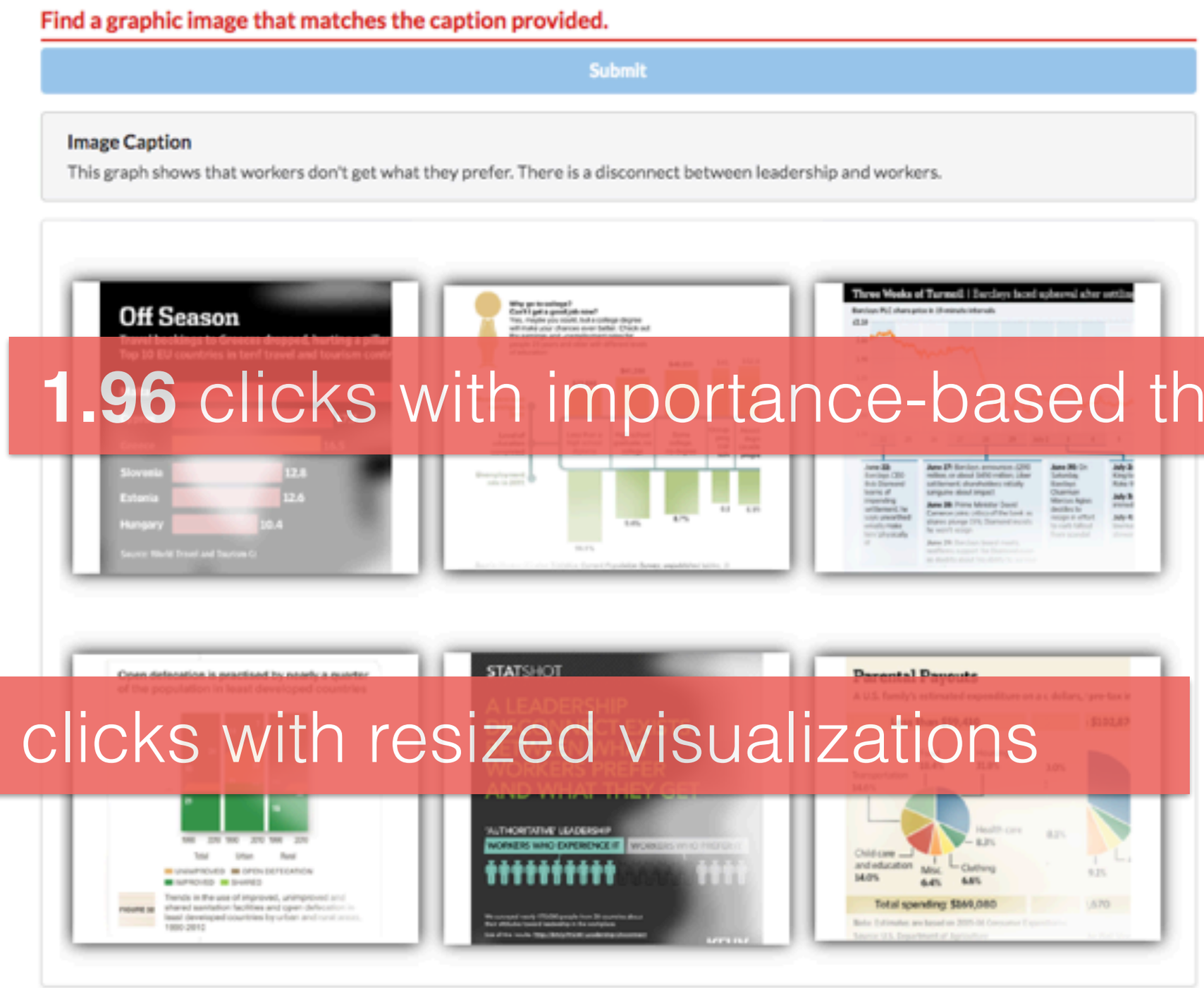
User evaluation



1.96 clicks with importance-based thumbnails

Bylinskii et al. [UIST 2017]

User evaluation



1.96 clicks with importance-based thumbnails

3.25 clicks with resized visualizations

Bylinskii et al. [UIST 2017]

Interactive design tool

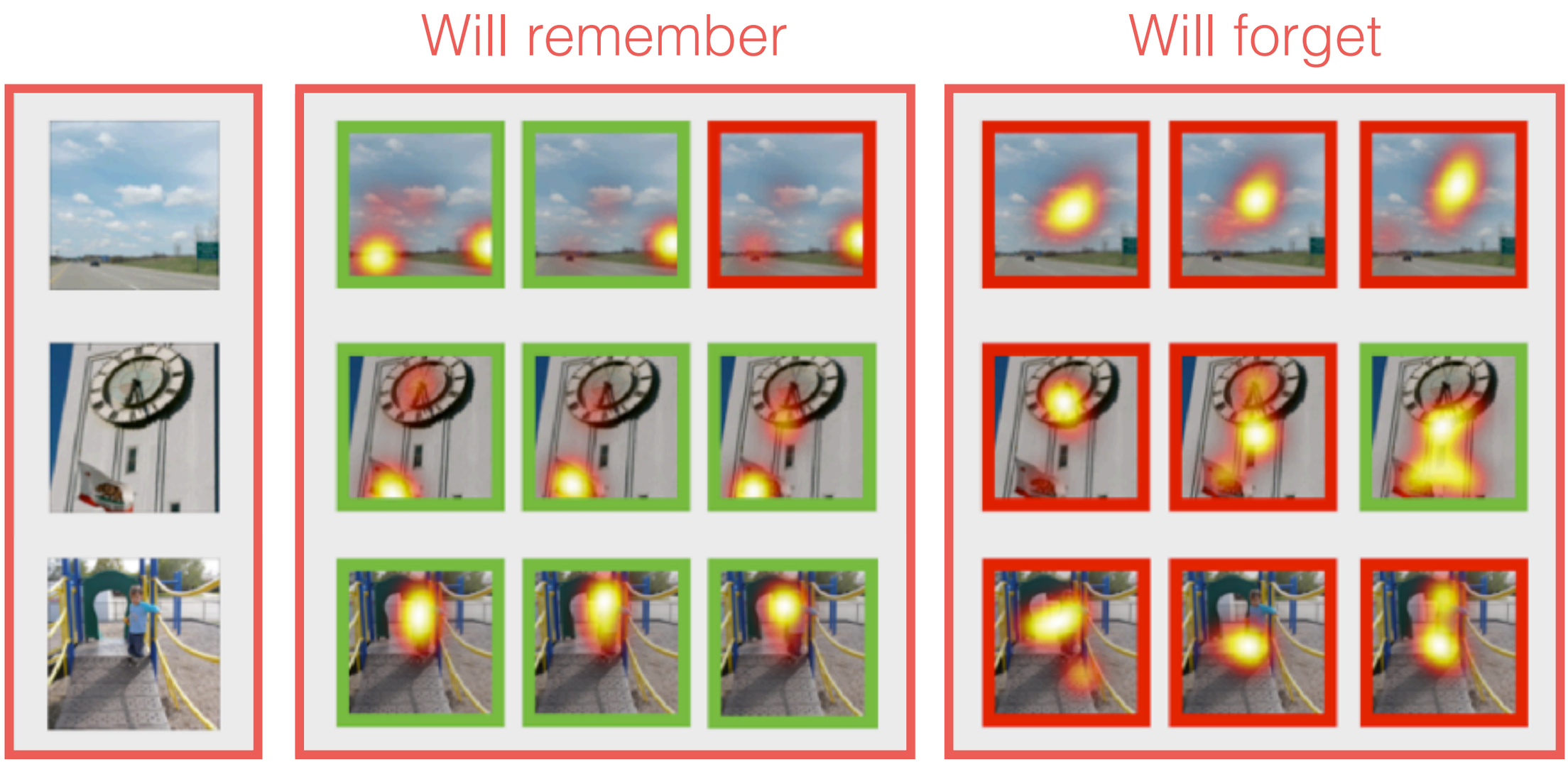
visimportance.csail.mit.edu

Personalized predictions

Personalized predictions

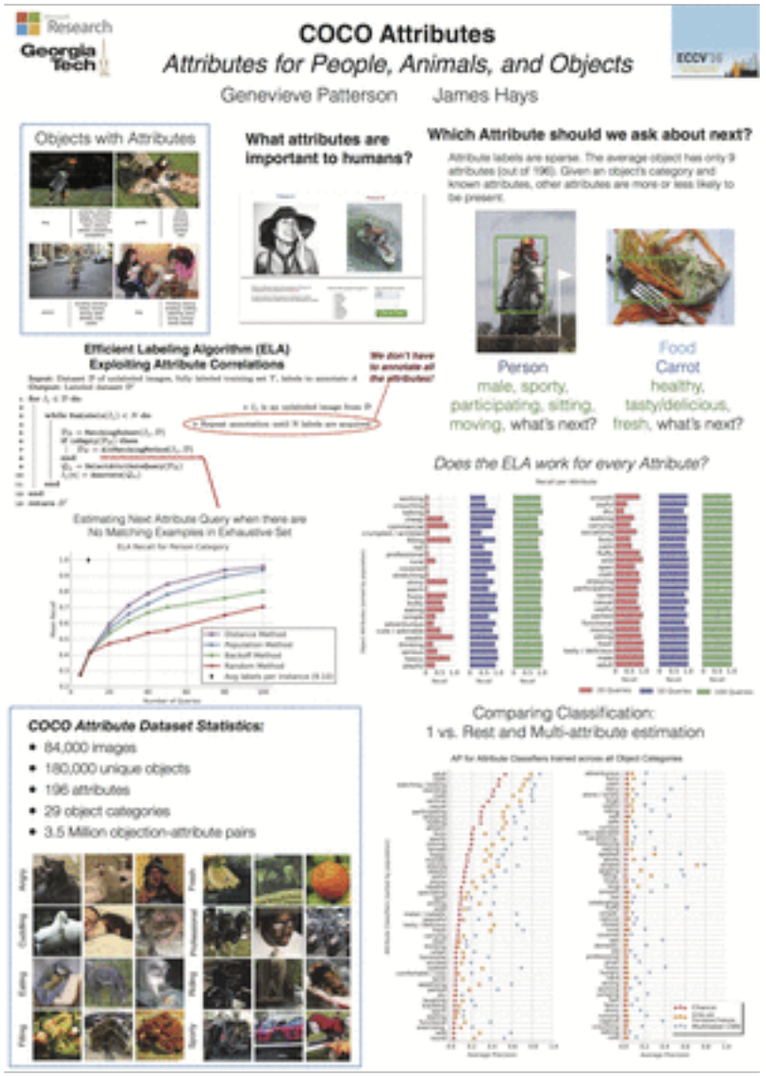
Personalized predictions

Personalized predictions

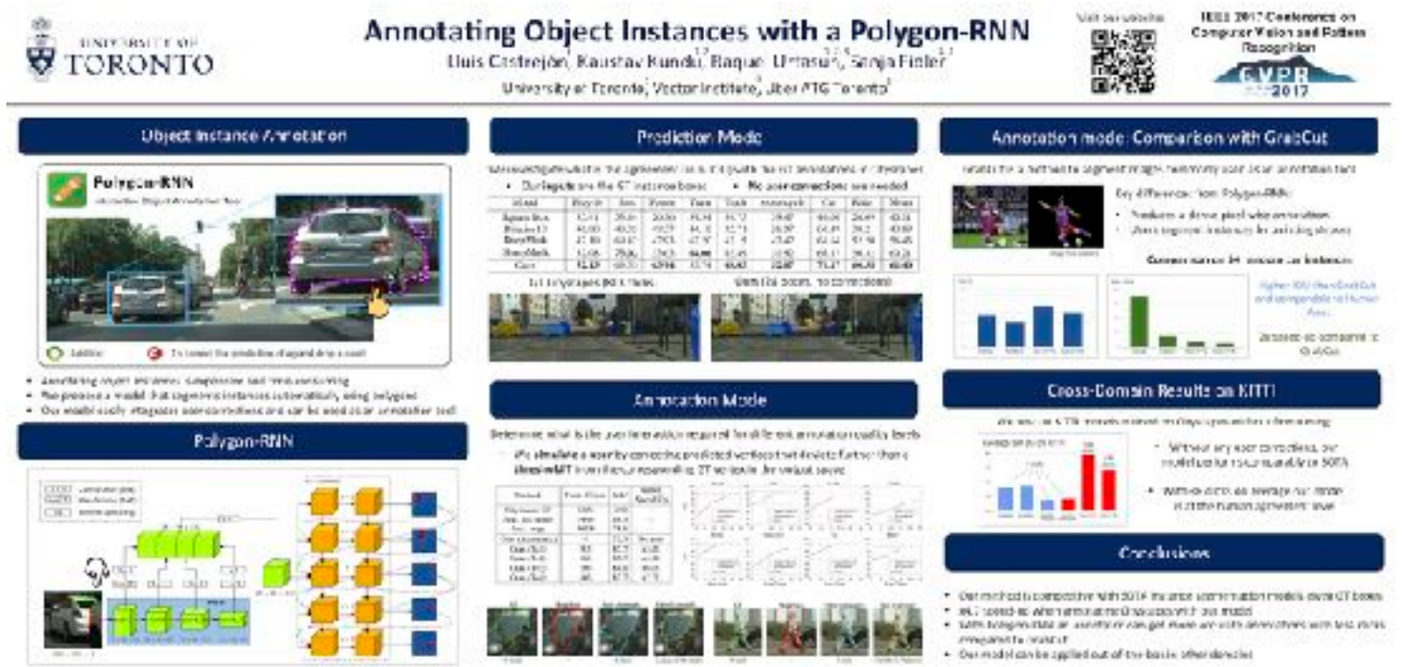


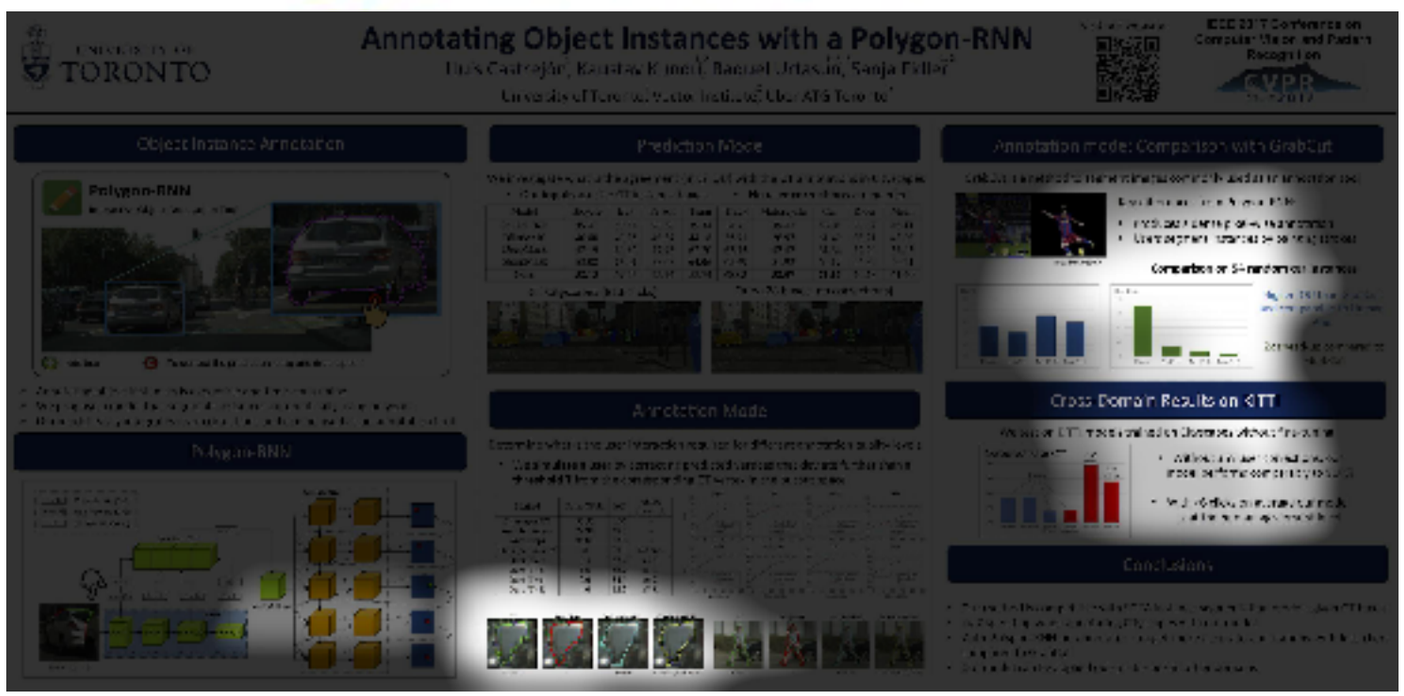
Bylinskii et al. [VR 2015]

Personalized thumbnails



Computing ZoomMaps





ZoomMaps approximate fixations

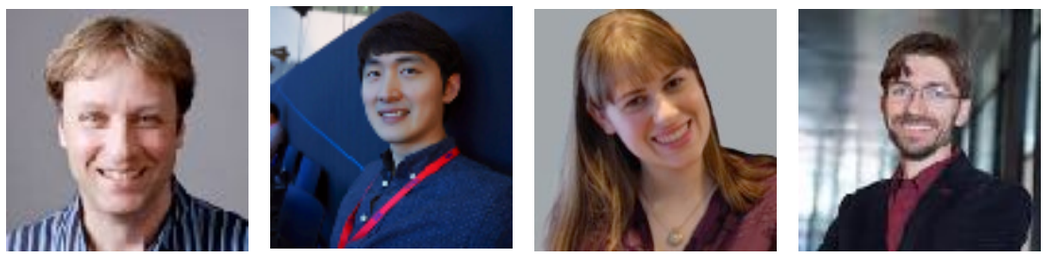
Average
ZoomMaps

Average
Fixation maps

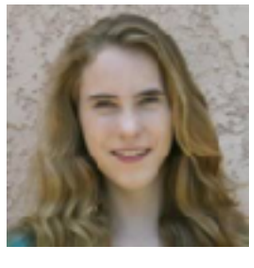
9:15 AM
SciApp
SCIENCE ROOM 04
BRIDGE THE GAP
Mr. Rubio
Question of the Day
Calendar
Class Resources
Announcements
Class Duties

my MIT advisors

my Adobe collaborators



my Harvard collaborators



my student collaborators

cognitive science

computer vision

computer graphics

computational photography

information visualization

human computer interaction

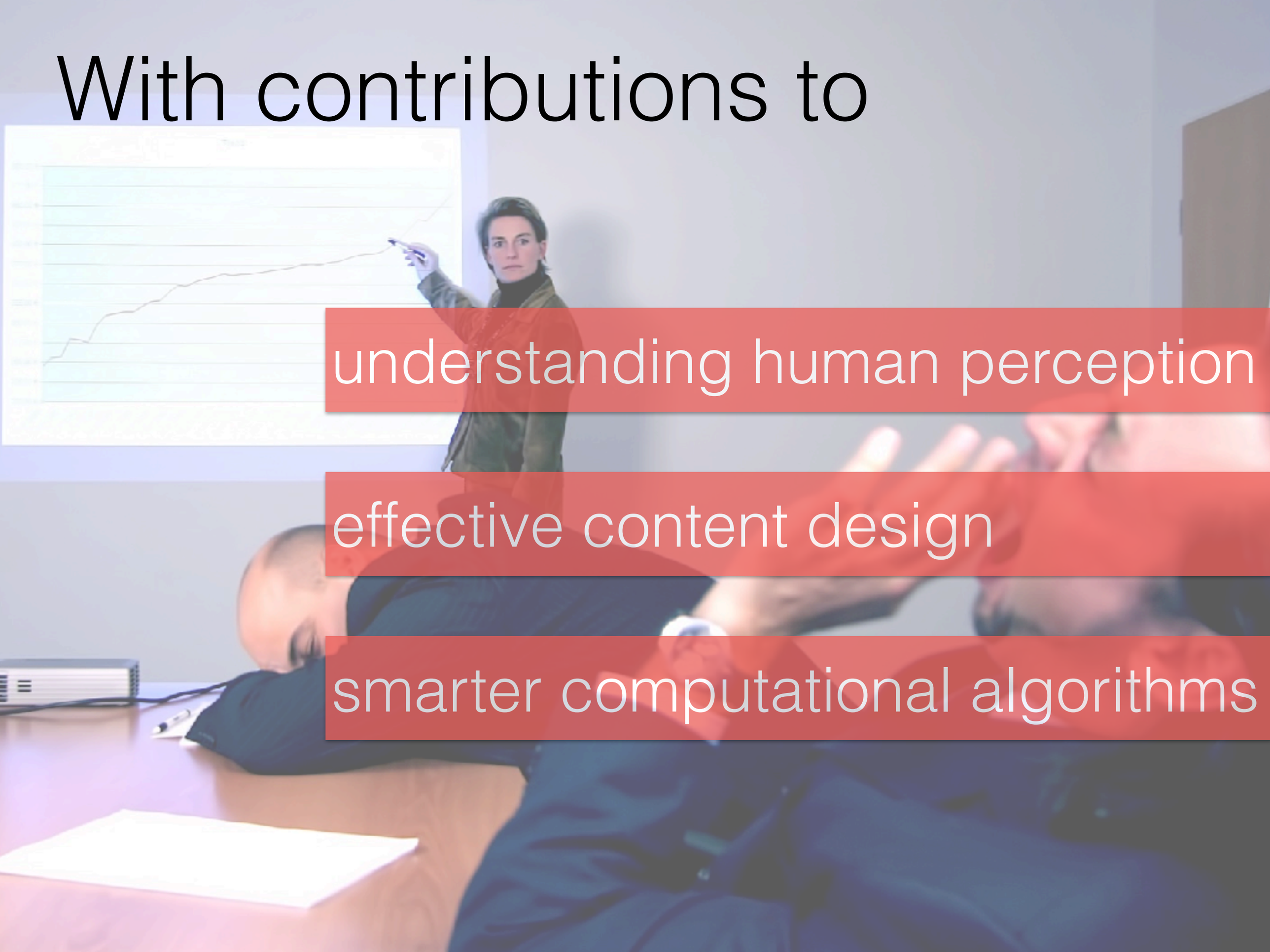
human perception

education tools

neuroscience

software development tools

With contributions to

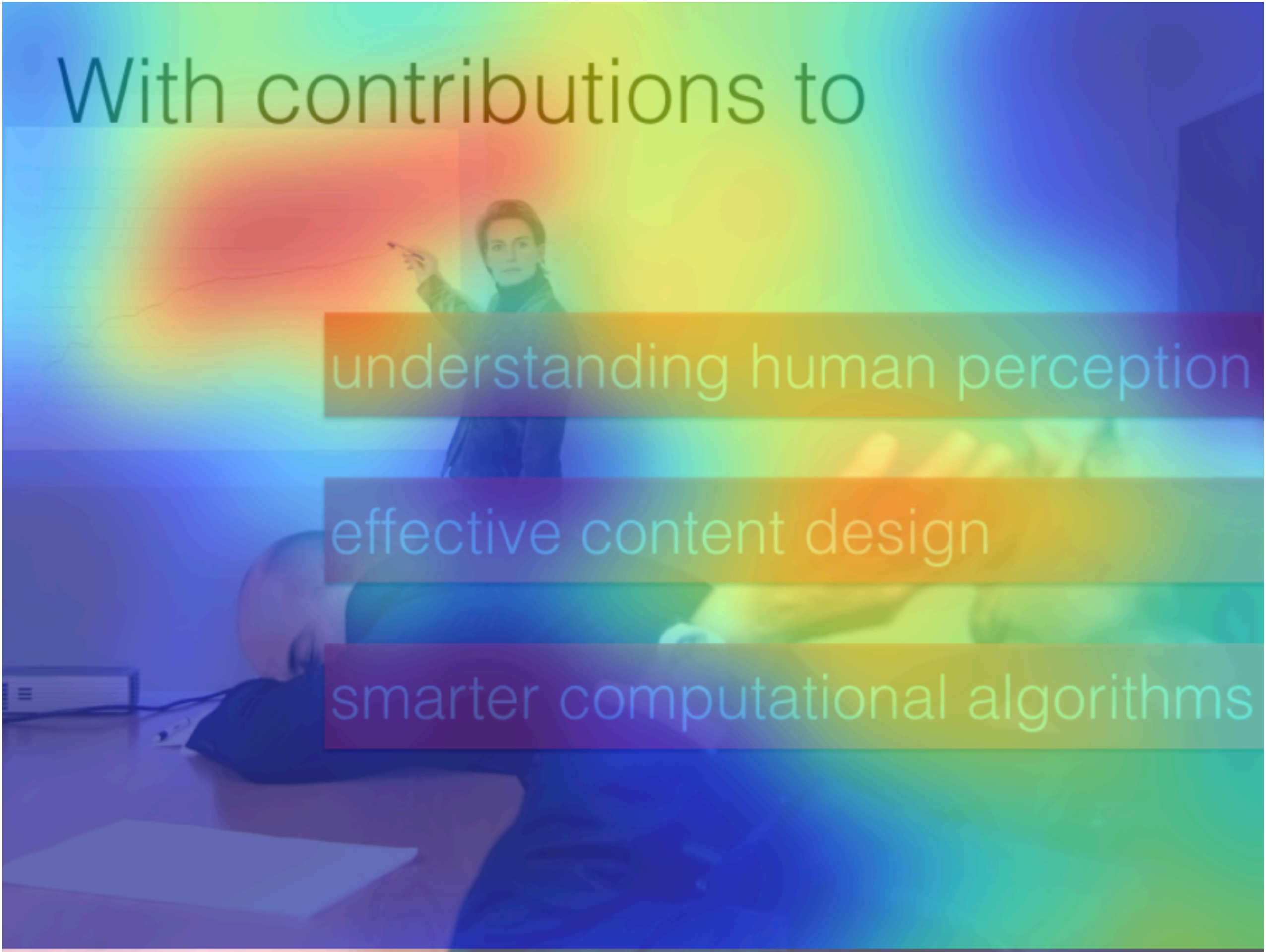


understanding human perception

effective content design

smarter computational algorithms

With contributions to
understanding human perception
effective content design
smarter computational algorithms


With contributions to
understanding human perception
effective content design
smarter computational algorithms

With contributions to

understanding human perception

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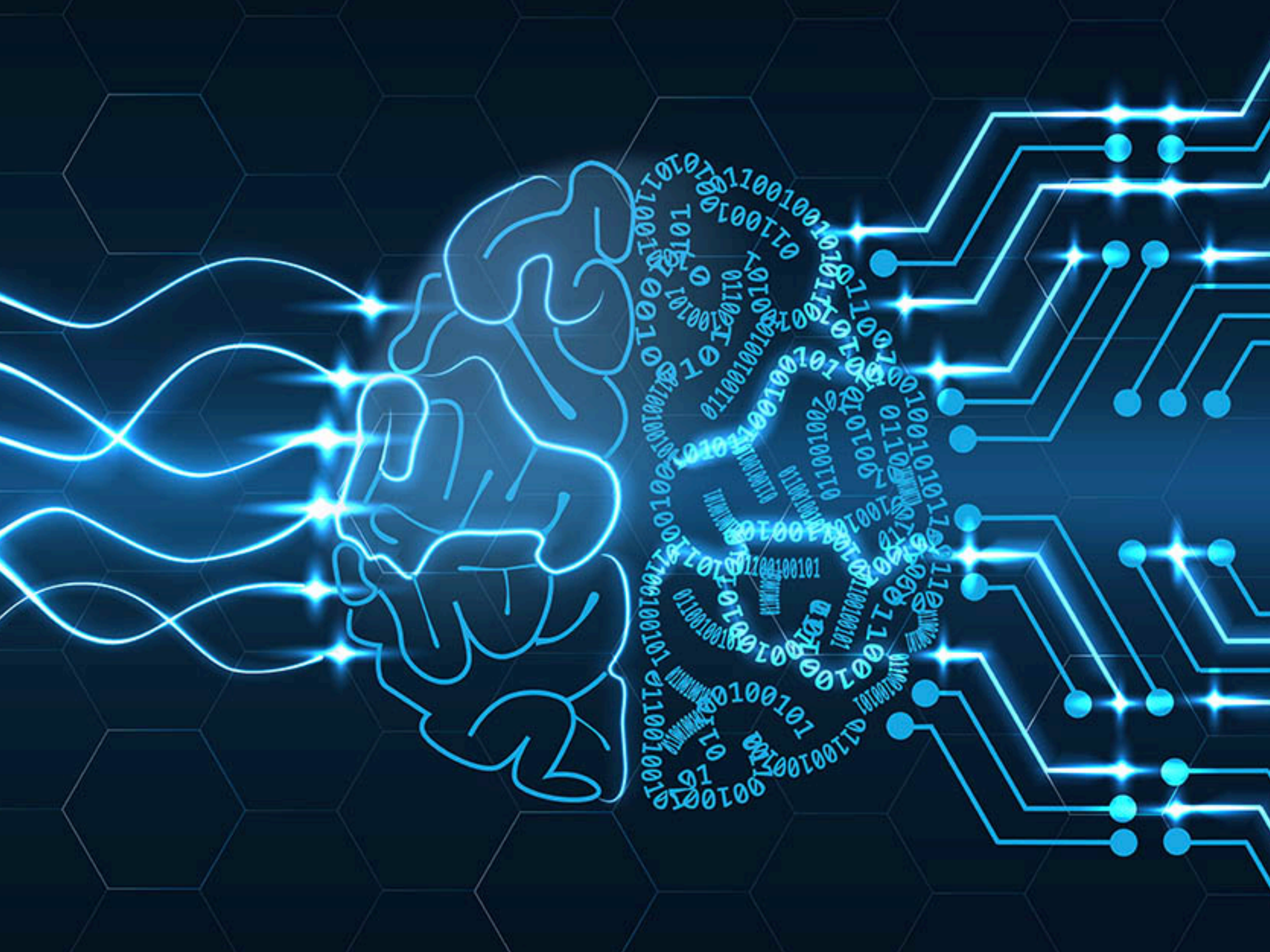
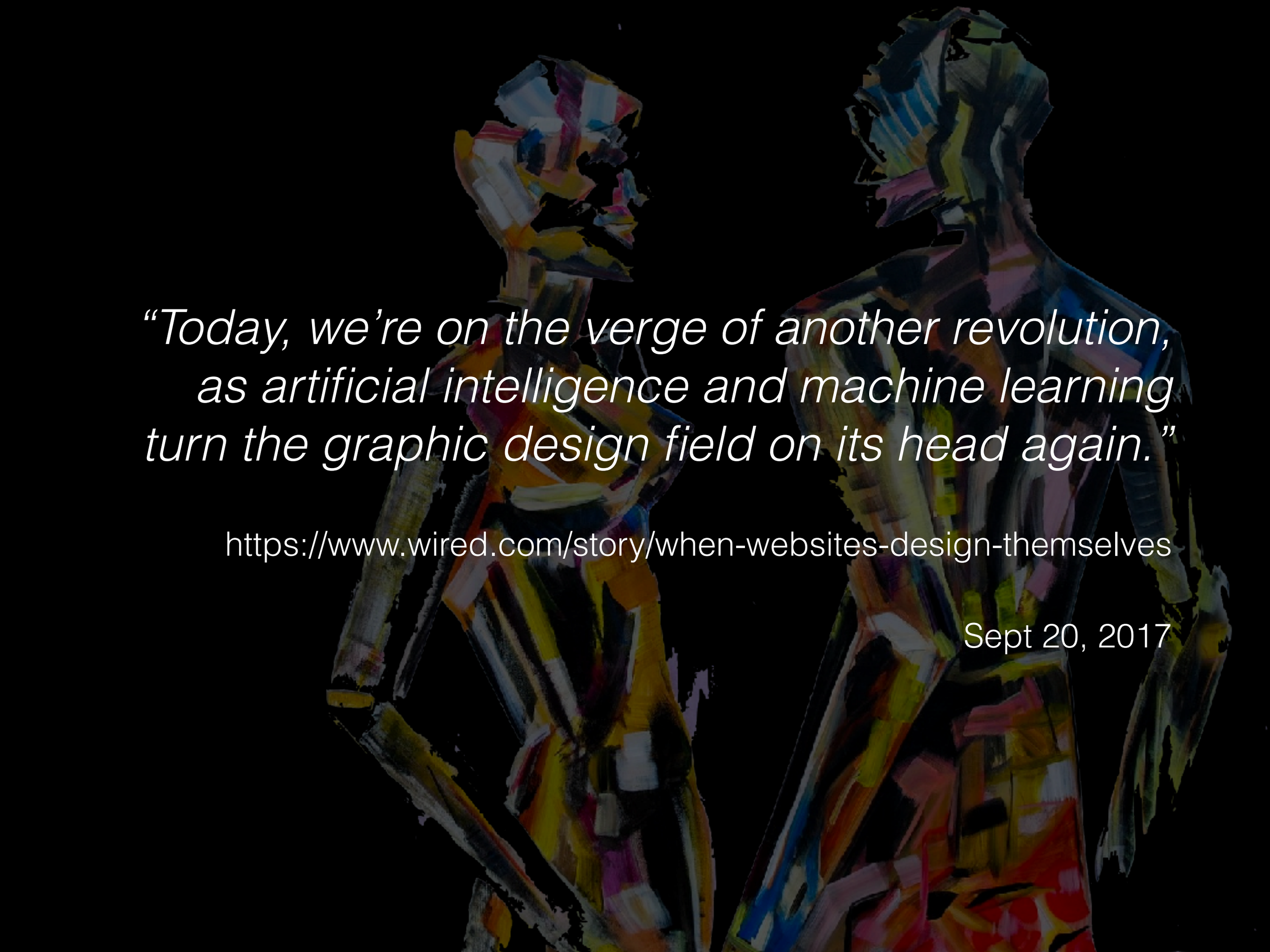




“Today, we’re on the verge of another revolution, as artificial intelligence and machine learning turn the graphic design field on its head again.”

https://www.wired.com/story/when-websites-design-themselves

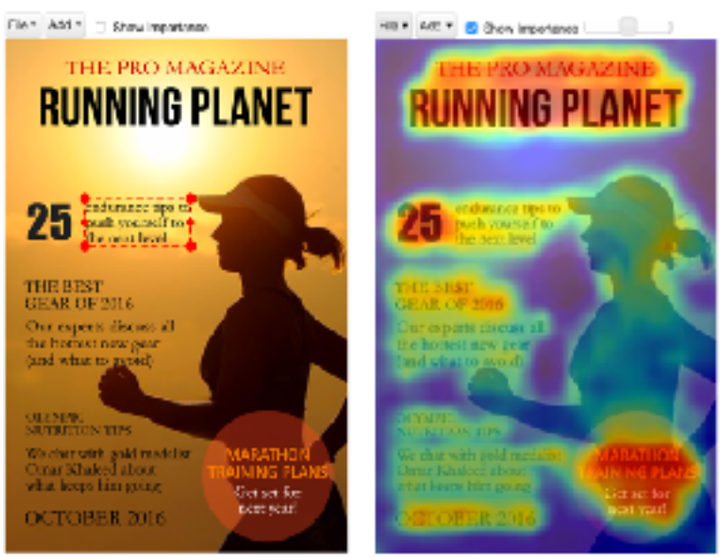
Sept 20, 2017

Multi-modal understanding

Topic prediction

Dense annotation

Attention Modeling



Summarization & Redesign