Urban Images and Computer Vision

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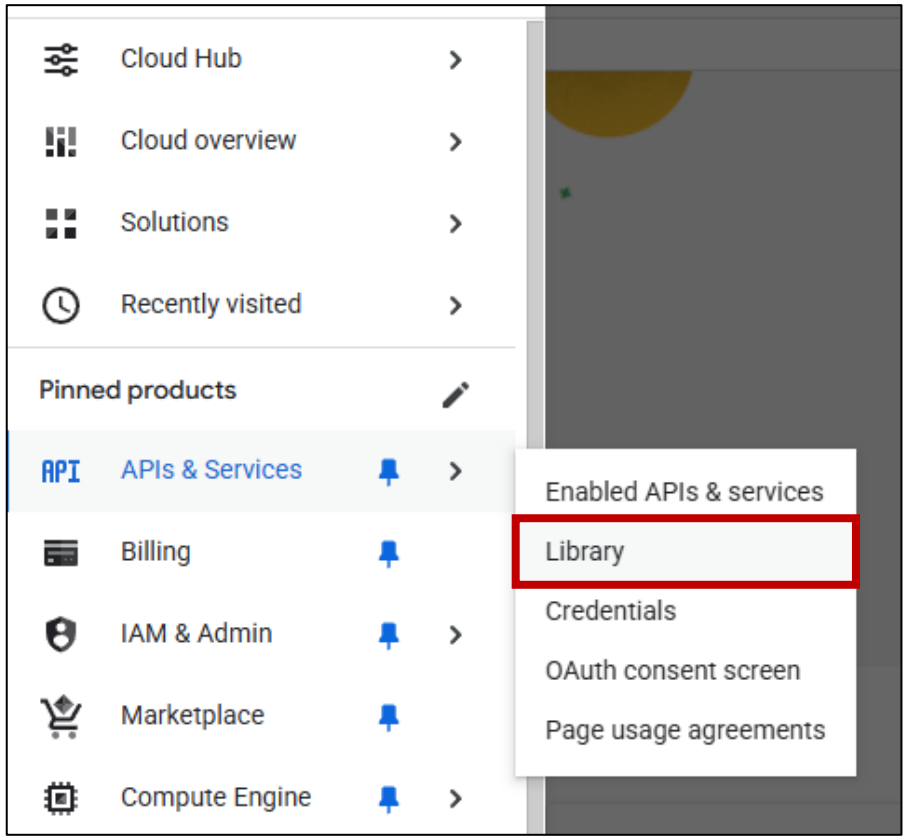
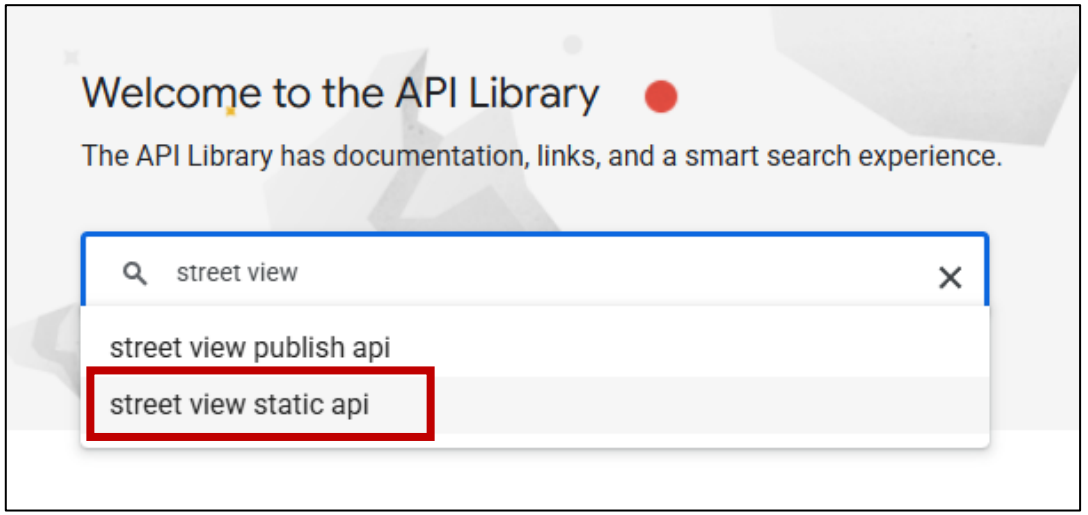
Module 4 in a nutshell

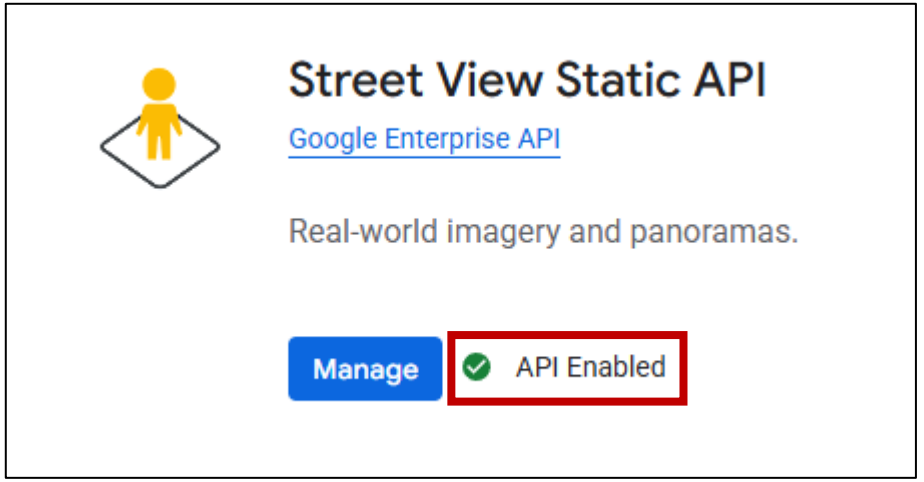
1. ~~Get Google API key.~~
2. Download street network data (OSM) and clean it.
3. Generate points along the edges. These will be where Google Street View (GSV) images will be downloaded.
4. Calculate the heading for each point.
5. Create a function that takes a point as input and download GSV images.
6. Apply a Computer Vision model to the images.
7. Merge the results back to the points from Step 2 for analysis.

- We will cover Steps 2-5 next Monday and Steps 6-7 next Wednesday.
- We will use Google Colab for the computer vision part (Steps 6-7).

Make Sure Street View Static API is Enabled

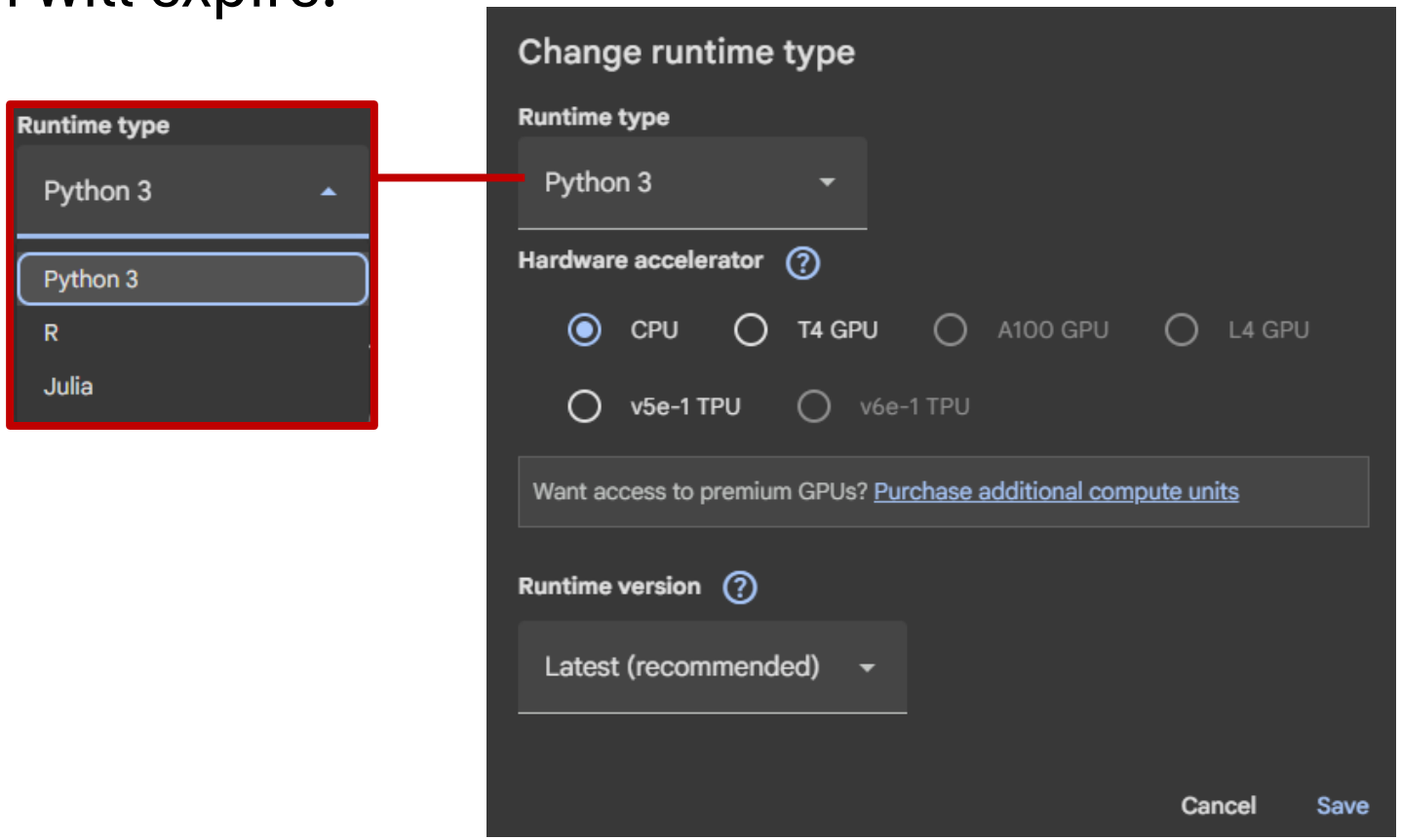






Google Colab

- Google Colab is a cloud-based Jupyter notebook service hosted by Google.
- The free tier has 12-hour session limit; after 12 hours of computation, your session will expire.



WHY DO STREET VIEW IMAGES MATTER IN URBAN PLANNING?

Built Environment

- The term ***built environment*** refers to human-made conditions including buildings, public infrastructure, transportation, and open space. It provides the setting for human activity (McClure et al. 2007).
- Built environment affects public health, public safety, environmental sustainability, economic vitality, tourism, and so on.

Traditionally we measured...

- Density
  - Population
  - Employment
  - Development
  - Intersections
- Accessibility
  - Jobs
  - Amenities
  - Public transit
  - Parks & Green
- Land use


With street view, we can measure...
5th St NW


With street view, we can measure...
Buildings
Trees
Streetlight
Cars
Street parking
Shared bikes
Sidewalk
Bike lane
Vehicular lanes


With street view, we can measure...
Sky view factor
Greenness at your eye level
Quality/design of street frontage
Sense of enclosure
Quality Of Sidewalk
5th St NW


With street view, we can measure...
Streetscape:
Physical layout and design of the street environment
5th St NW


KENWOOD

Google Street View Images

Street View Images API

- Google Street View (GSV)
- ~~Bing Maps Streetside View~~
- Mapillary: a platform for sharing crowdsourced geotagged street view images; acquired by Meta in 2020.

Compare Google and Mapillary street view images.

Google Street View Images

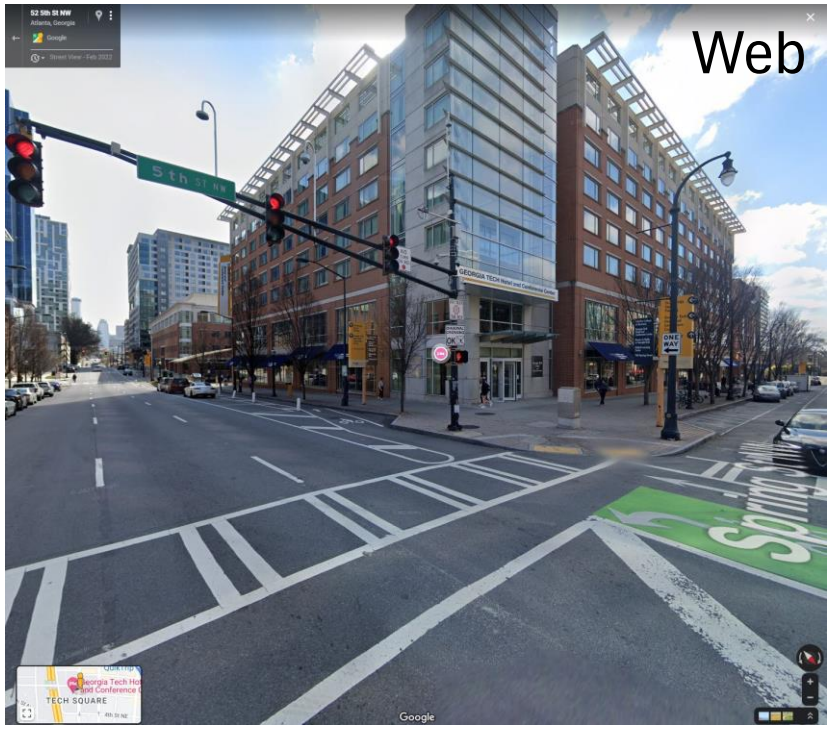
- Images taken at roughly 10-meter (or 33-foot) intervals from cameras that are (often but not always) mounted on car roof.
- 360-degree image in all directions.
- Have coverage both in US and internationally and can go back in time.

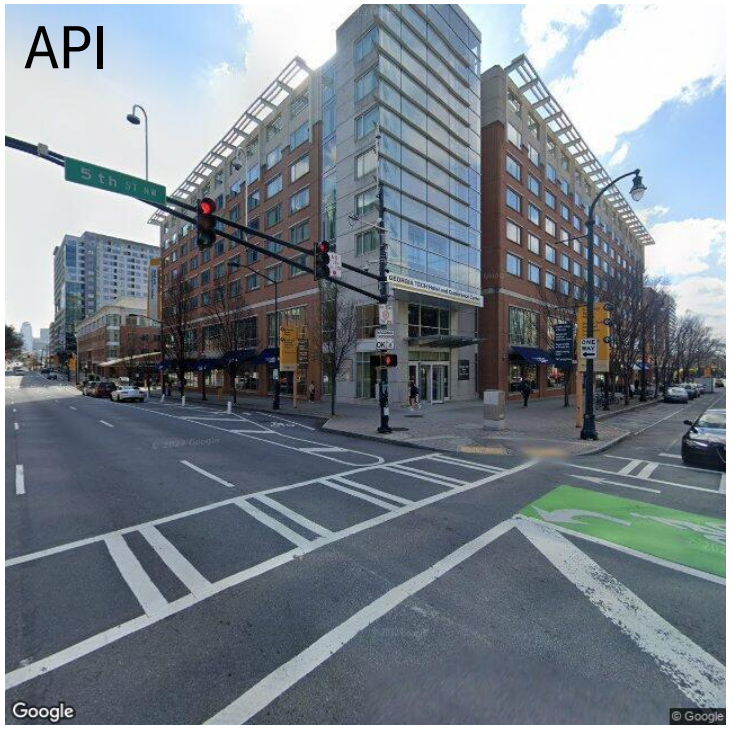
Google Street View Images

- Around 2010, planning studies started using Google Street View (GSV) images to audit street environments.
- In early studies, human auditors were looking at GSV and did manual audits.
- Recent studies are increasingly using computer vision instead of manual audits.

Google Street View Images

- GSV you see on the web is free, but **their API is NOT FREE!**
- Free usage cap per month is **10,000** images. After that, **7.00** USD per **1000** images.
- Always monitor your API usage!





Warning: Google is not happy about what we are doing

Google Maps APIs Terms of Service (https://cloud.google.com/maps-platform/terms/)

3.2.3 *Restrictions Against Misusing the Services*.

(a) *No Scraping*. Customer will not export, extract, or otherwise scrape Google Maps Content for use outside the Services. For example, Customer will not: (i) pre-fetch, index, store, reshare, or rehost Google Maps Content outside the services; (ii) bulk download Google Maps tiles, Street View images, geocodes, directions, distance matrix results, roads information, places information, elevation values, and time zone details; (iii) copy and save business names, addresses, or user reviews; or (iv) use Google Maps Content with text-to-speech services.

GSV API query format

https://maps.googleapis.com/maps/api/streetview?
size=640x640&location= 47.5763831,-122.4211769
&fov=90&heading=70&pitch=0&key=YOUR_API_KEY

- **Size**: image size; capped at 640x 640 pixels.
- **Location**: latitude and longitude.
- **fov**: (default 90): the field of view of the image.
- **Heading**: direction of the camera.
  (0=North, 90=East, 180=South, 270=West, 360=North)
- **Pitch** (default 0): up/down angle of the camera.
- **key**: Your API key.

Try it

- This URL (with your key added) will give you an image at Tech Square.

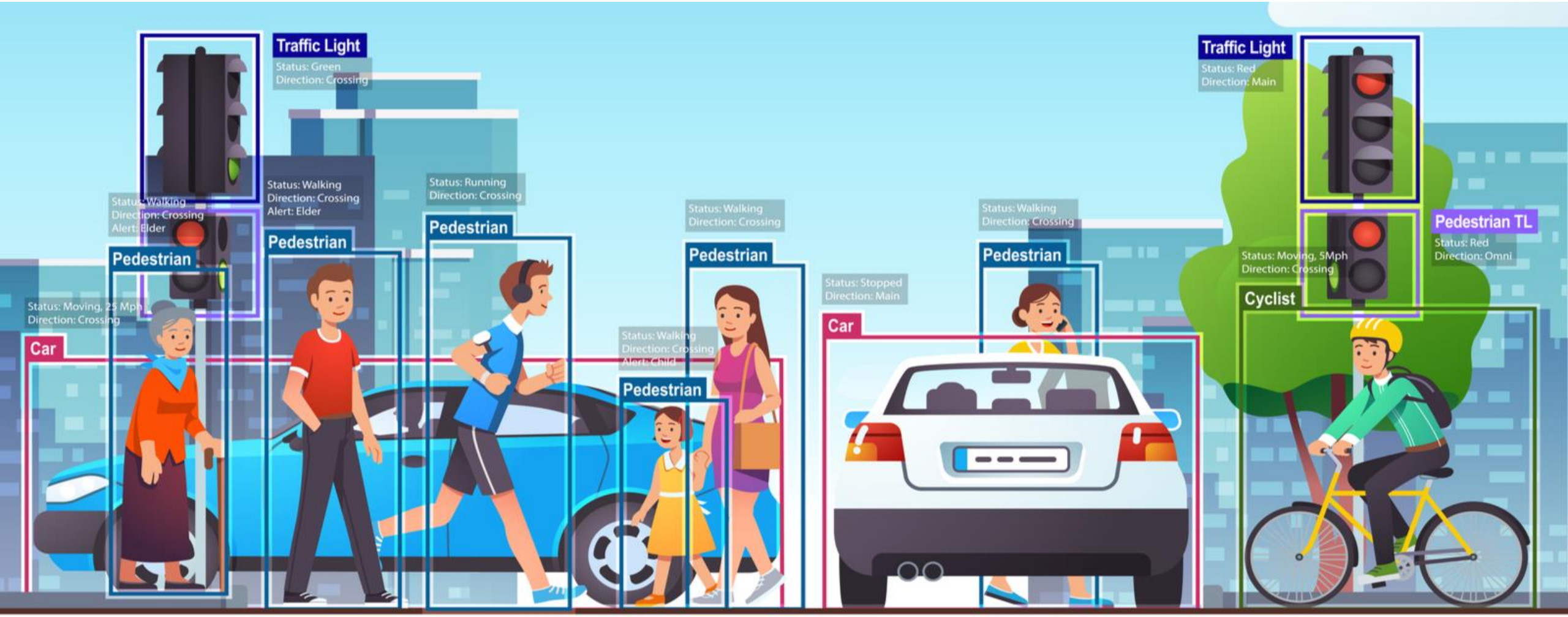
  https://maps.googleapis.com/maps/api/streetview?size=640x640&location=33.7768249,-84.388767&heading=224.96&fov=90&pitch=0&key=YOUR_API_KEY

- Try different values for heading, fov, and pitch.

COMPUTER VISION

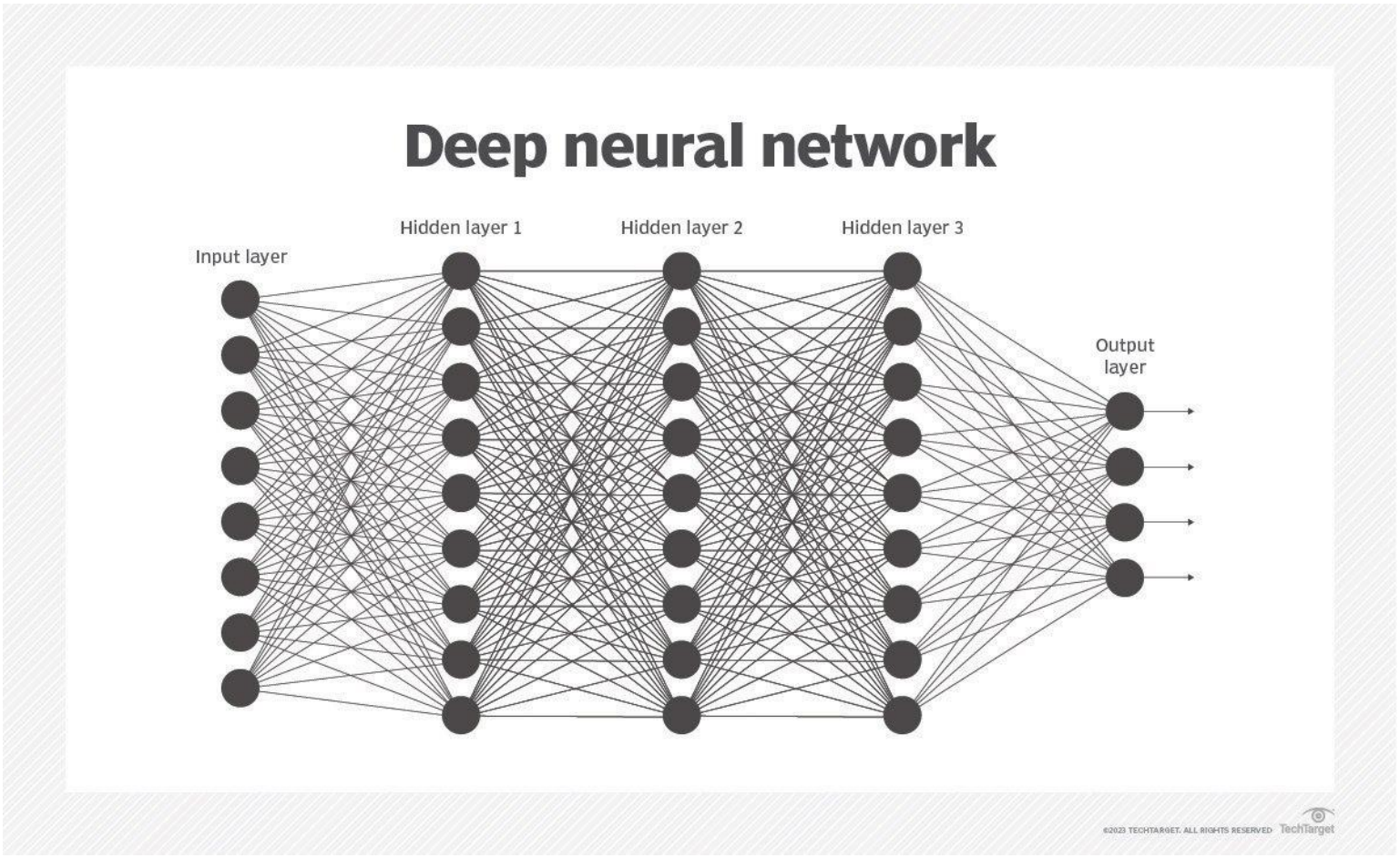
Computer Vision

- A field of Artificial Intelligence (AI) that teaches computers to understand and interpret visual information.



Deep Learning

- Deep learning is part of a broader family of AI methods based on **artificial neural networks**.



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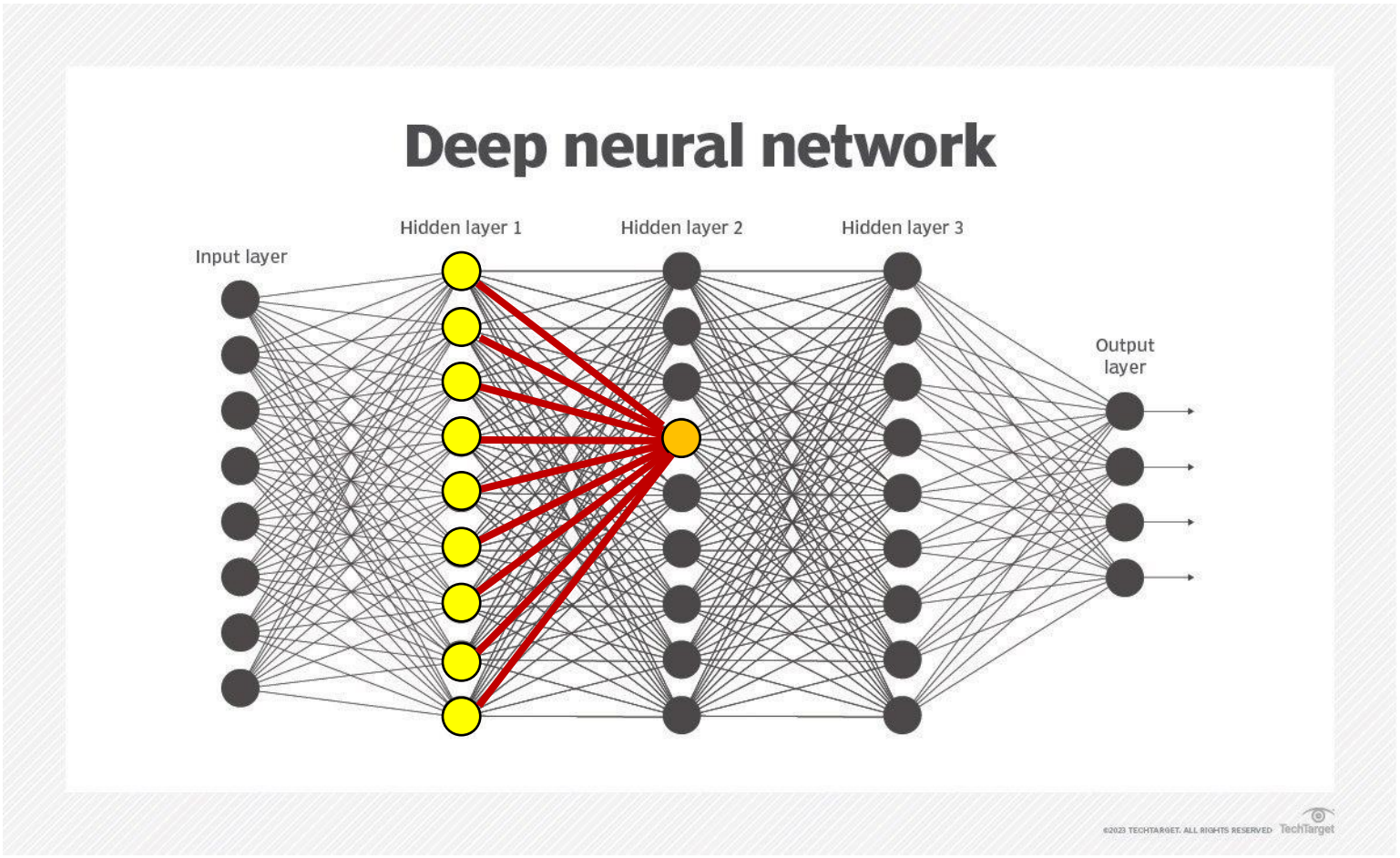
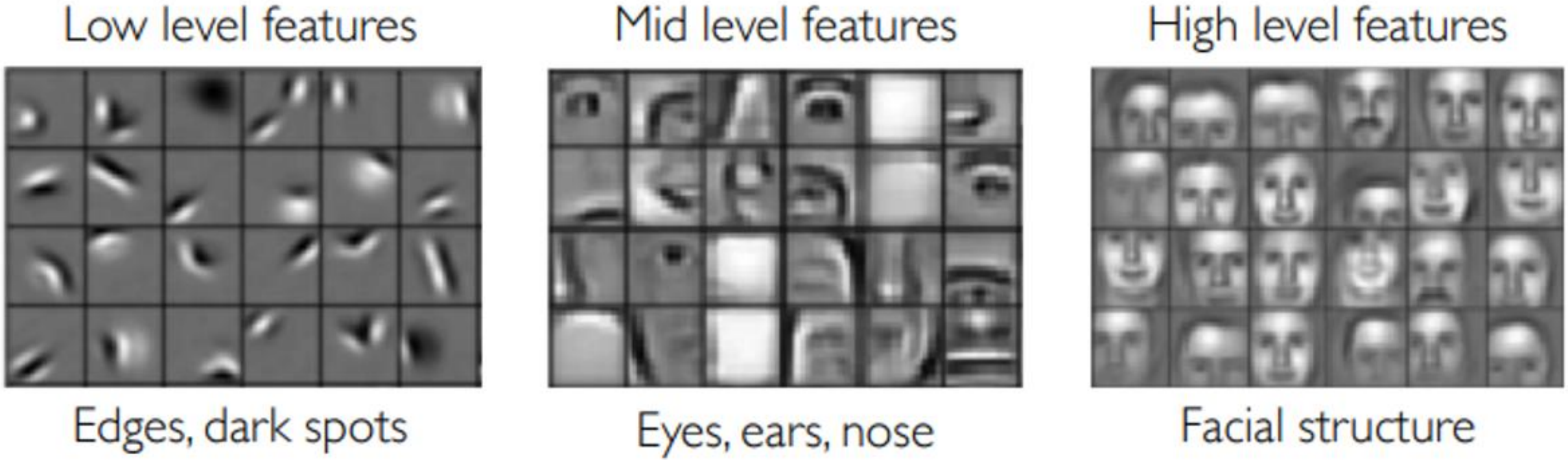


Key Concepts of Deep Learning

- **Representation learning**:

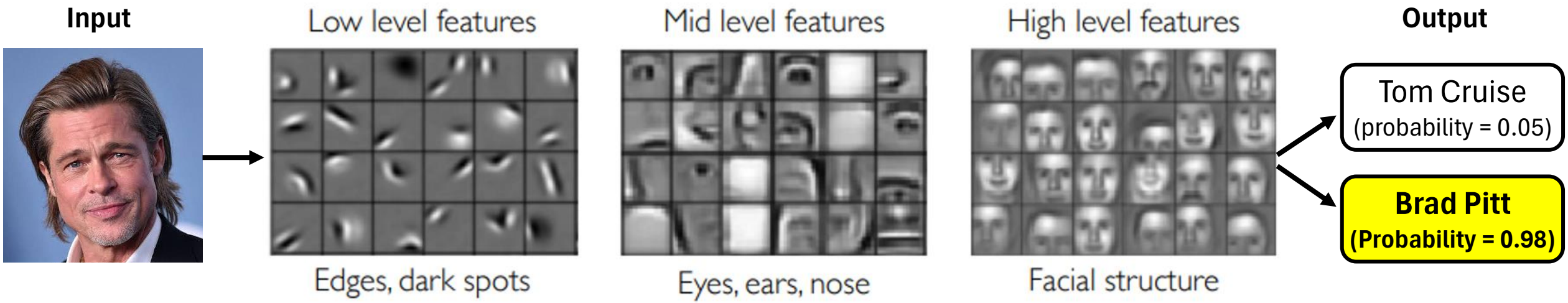
  The multiple layers can learn different levels of representation of the data, leading to more effective feature extraction.



Key Concepts of Deep Learning

- **Automatic Feature Engineering:**

  Eliminates the manual work involved in feature extraction, a time-consuming step in traditional machine learning.



Applications of Deep Learning

- **Computer Vision**
  - Image recognition and classification
  - Image segmentation
  - Object detection
  - Autonomous vehicles
- **Natural Language Processing**
  - Machine translation
  - Text generation
  - Sentiment analysis
  - Conversational AI (Chatbots)
- **Speech Recognition**
- **Medical Diagnosis**
- **Recommendation Systems**

Image Classification

- [3D Visualization of a Convolutional Neural Network (adamharley.com)]

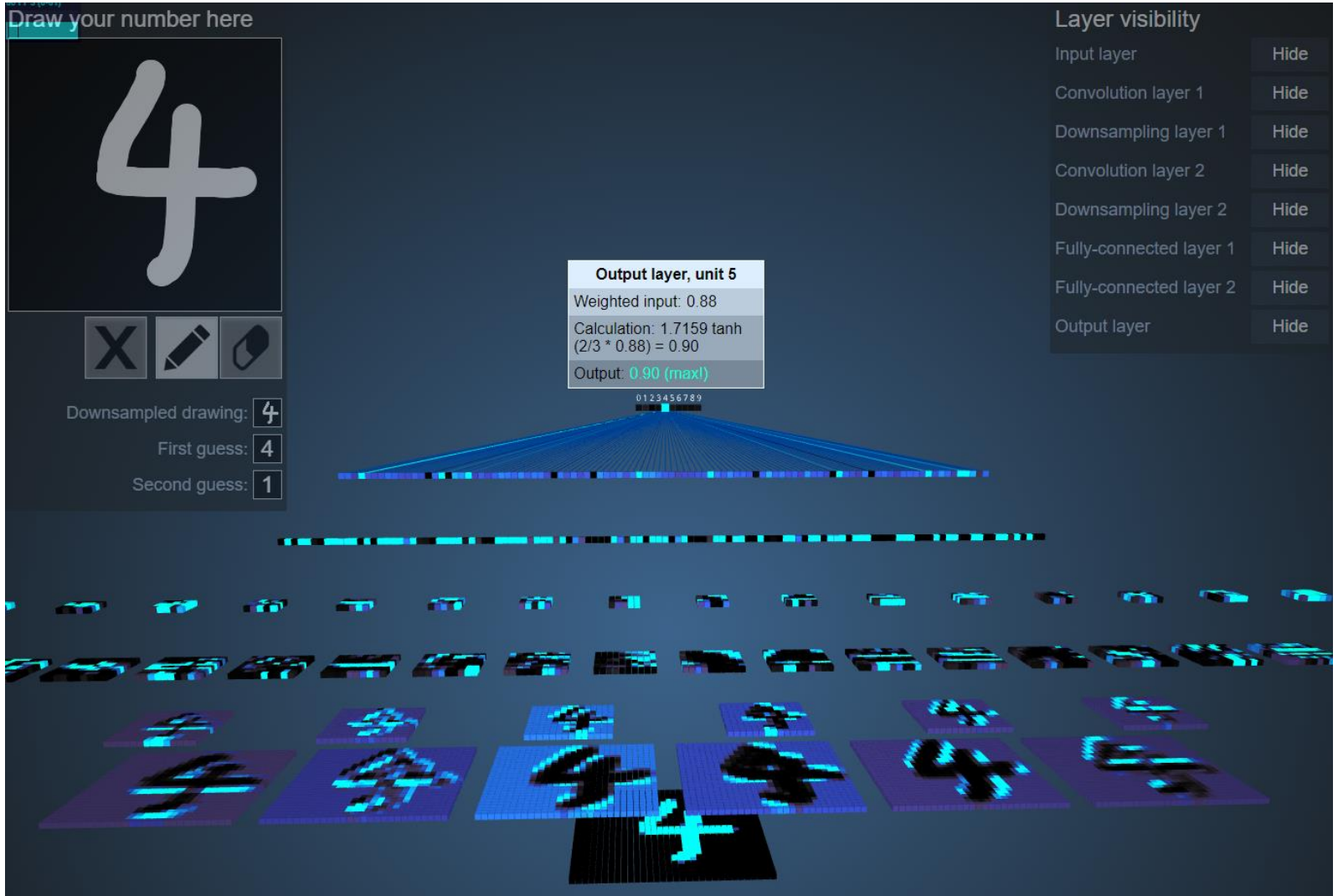
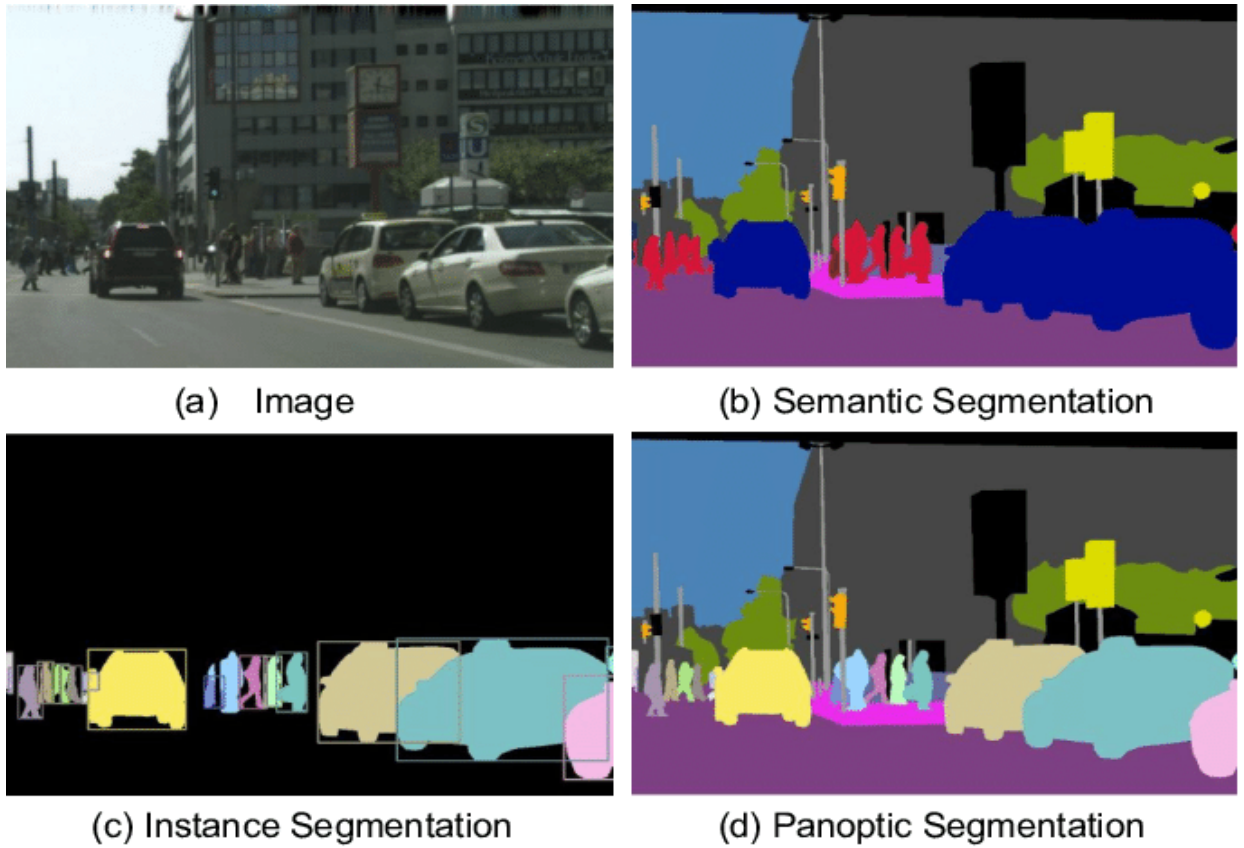


Image Segmentation

- Segmentation models detect 'Things' and/or 'Stuff' from an image.
  - ***Things***: countable objects such as person, bike, and car.
  - ***Stuff***: uncountable region of identical texture, such as sky and road.

Image Segmentation

- ***Semantic Segmentation***: Classifies each pixel of an image into a class (= ***stuff***).
- ***Instance Segmentation***: Detects objects and distinguishes instances (= ***things***).
- ***Panoptic Segmentation***: Combines the two methods above (= ***stuff*** + ***things***).



(a) Image

(b) Semantic Segmentation

(c) Instance Segmentation

(d) Panoptic Segmentation

Computer Vision in Autonomous Vehicle Technology

- Nvidia’s lane detection model
- Tesla’s lane and object detection model