Gait Analysis

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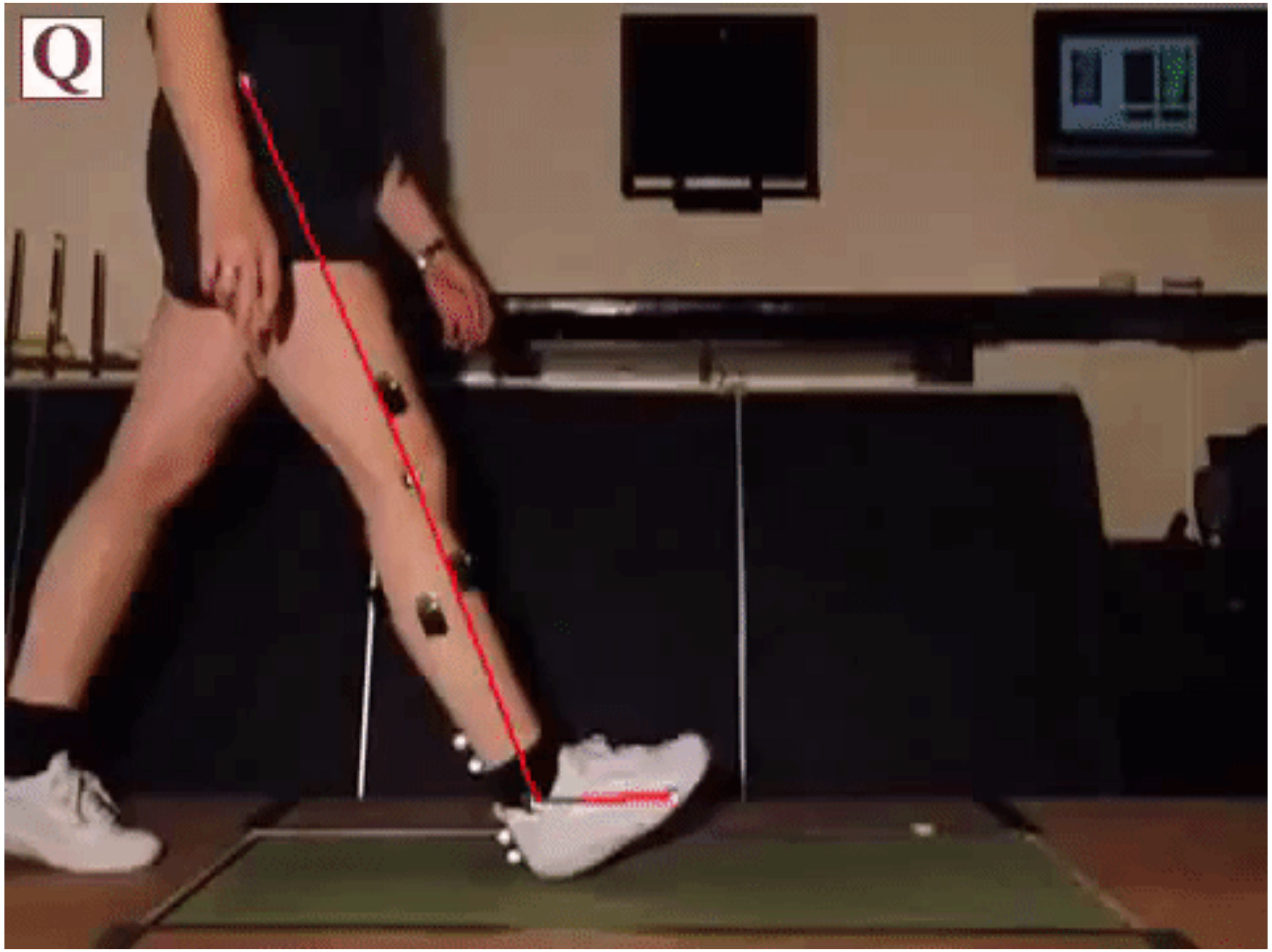
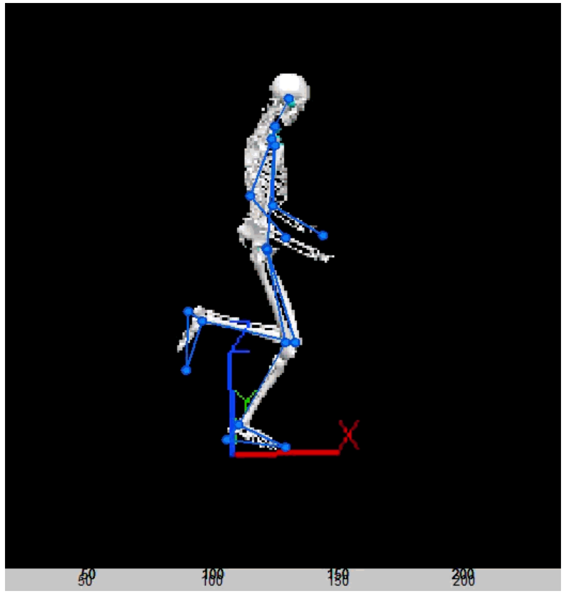


Gait Analysis



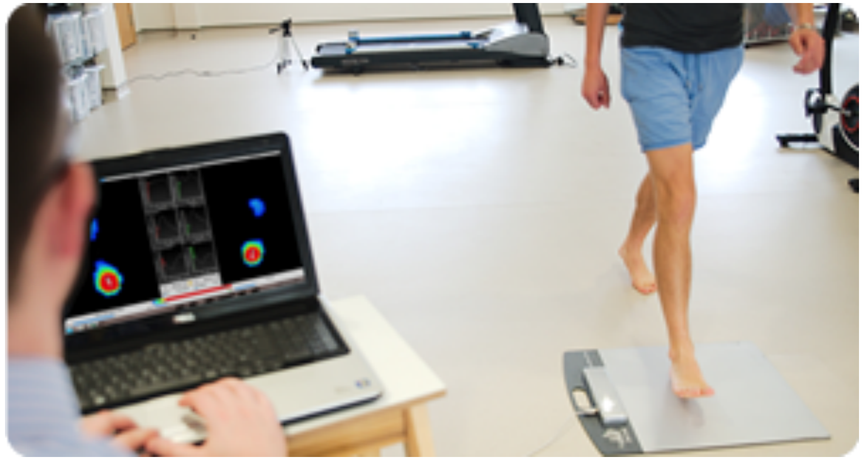
Definition: Gait analysis is the systematic study of animal locomotion, more specifically the study of human motion, using the eye and the brain of observers, augmented by instrumentation for measuring body movements, body mechanics, and the activity of the muscles.

Why?

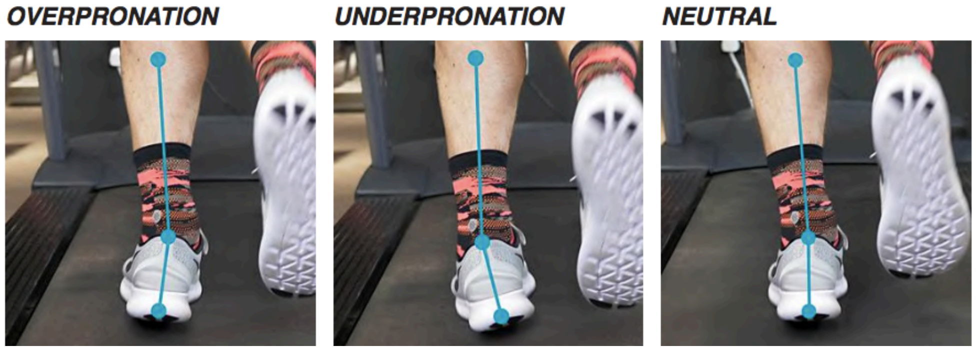
Under normal conditions when no dysfunctional factors impact on gait, the act of walking operates at a virtually unconscious level.

Fields of application

Medical diagnostics: Pathological gait may reflect compensations for underlying pathologies, or be responsible for causation of symptoms in itself. Cerebral palsy and stroke patients are commonly seen in gait labs. The study of gait allows diagnoses and intervention strategies to be made, as well as permitting future developments in rehabilitation engineering.



Find the correct shoes for runners: Pronation refers to the way in which your foot rolls inwards as it strikes the floor. It's your body's way of distributing impact, and a natural part of the gait cycle. Understanding your pronation type is important for selecting the right type of running shoe and ultimately could help you to avoid injury.



Fields of application

Recognize a person: Human gait is a feature of a person that is determined by, among other things, an individual's weight, limb length, footwear, and posture combined with characteristic motion. Hence, gait can be used as a biometric measure to recognize known persons and classify unknown subjects.

What’s new?

Action recognition: Recognize the action in a scene. It can be useful to detect criminals, illegal actions, potential threats.

Examples:

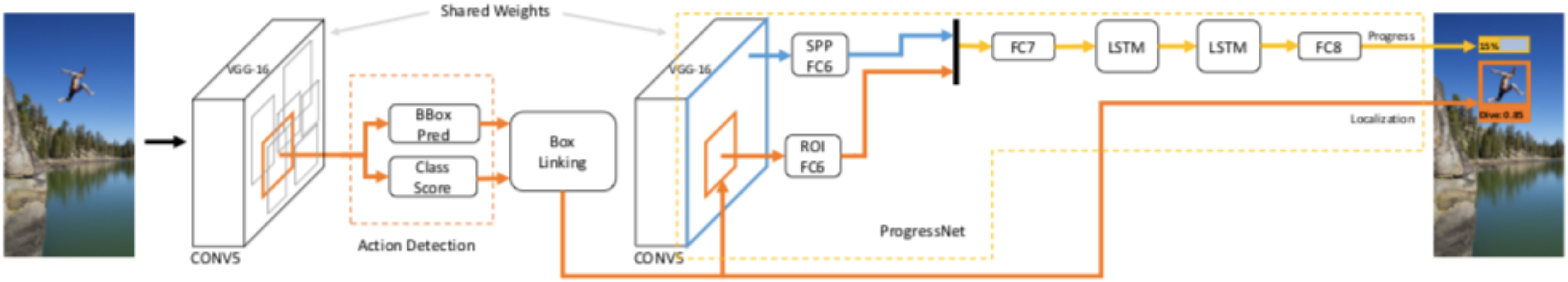
Hold a gun

Violence

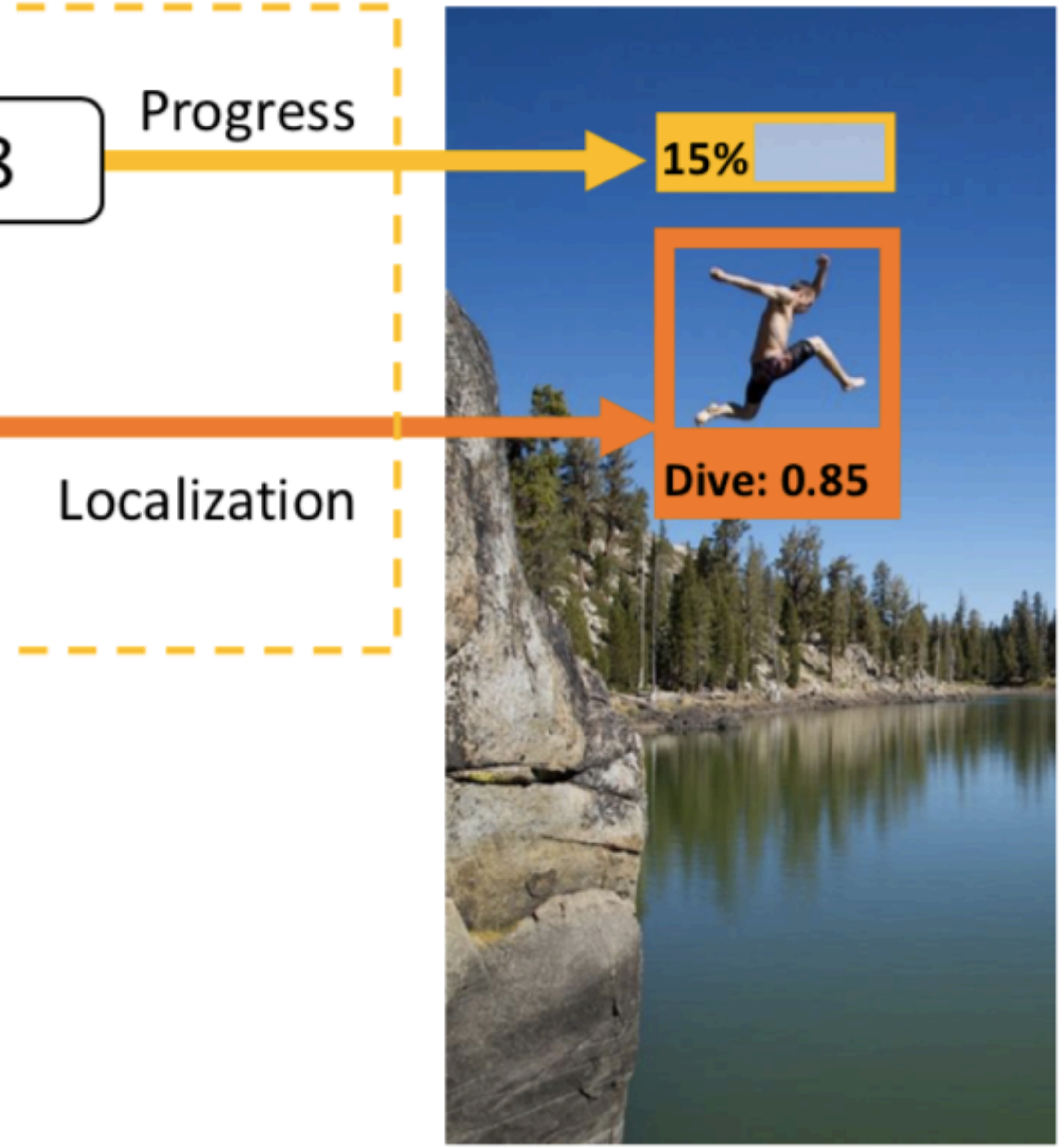
What's new?

Paper: *Am I Done? Predicting Action Progress in Videos* (Federico Becattini, Tiberio Uricchio, Lorenzo Seidenari, Alberto Del Bimbo, Lamberto Ballan)(2018)

They predict action progress in videos. They used ProgressNet, capable of predicting when an action takes place in a video, where it is located within the frames, and how far it has progressed during its execution.



Am I Done? Predicting Action Progress in Videos



What parameters we need?

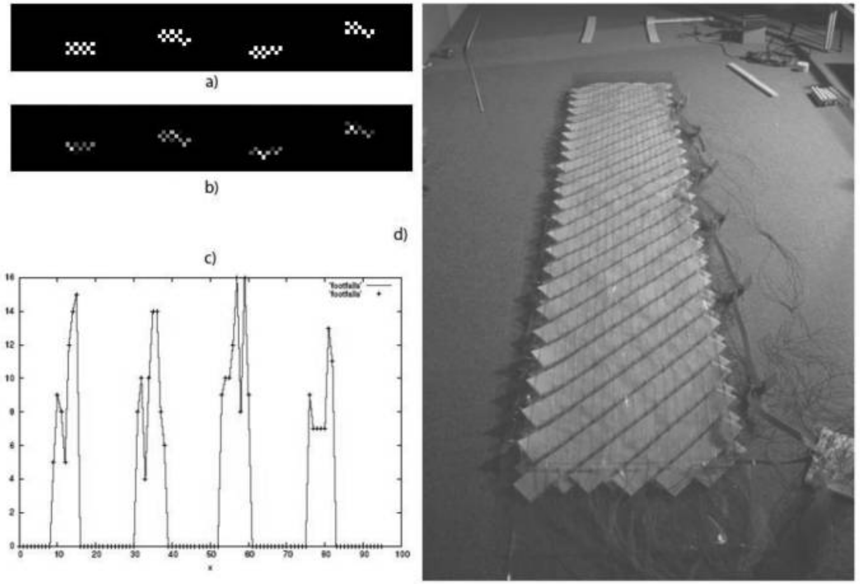
- Stride velocity
- Step length
- Stride length
- Cadence
- Step width
- Step Angle
- Step time
- Swing time
- Stance time
- Traversed distance
- Gait autonomy
- Stop duration
- Existence of tremors
- Fall
- Accumulated attitude
- Route
- Gait phases
- Body segment orientation
- Ground Reaction Forces
- Joint angles
- Muscle force
- Momentum
- Body posture

What parameters we need?

- **Stride velocity:** it can describe the attitude and the behavior of the sobject;
- **Step length:** it is the short step length, obtained by the linear distance between two successive placements of the same foot;
- **Stride length:** or long length obtained by the linear distance between the placements of both feet;
- **Cadence:** or rhythm, is the number of steps per time unit;
- **Step width:** it is the linear distance between two equivalent points of both feet;
- **Step angle:** it is the direction of the foot during the step;
- **Gait phases:** as the phases of the steps;
- **Body posture:** in terms of bending, symmetry etc.

Objective Techniques Used for Gait Measuring

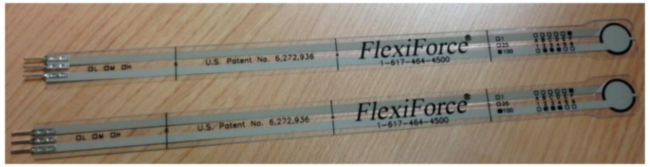
- **Floor sensors:** sensors are place along the floor on the so called “force platforms” or instrumented walkways where gait is measured by pressure or force sensors and moment transducers when the subject walks on them.



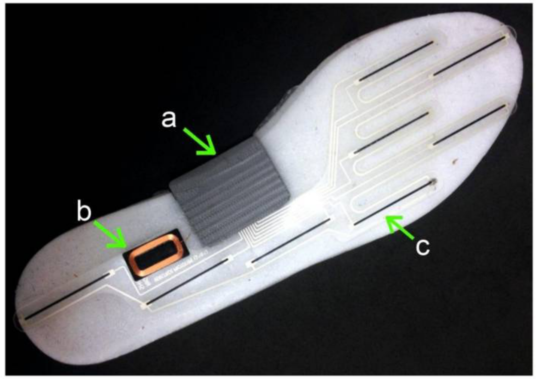
(a) step recognized, (b) time elapsed in each position; (c) profiles for heel and toe impact; and finally (d) image of the prototype sensor mat on the floor.

- **Wearable sensors:** these are placed on various parts of the patient's body, such as the feet, knees or hips to measure different characteristics of the human gait.

Example of pressure sensor



(a) inertial measurement unit; (b) flexible goniometer; (c) pressure sensors

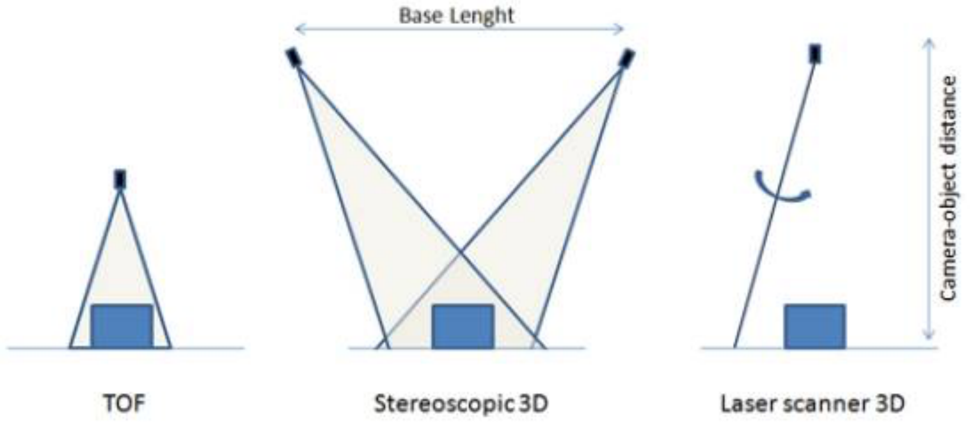


(a) inertial sensor, Bluetooth, microcontroller and battery module; (b) coil for inductive recharging; and (c) pressure sensors

Objective Techniques Used for Gait Measuring

- **Image processing:** The typical IP system is formed by several digital or analog cameras with lens that can be used to gather gait-related information. Techniques such as threshold filtering which converts images into black and white, the pixel count to calculate the number of light or dark pixels, or background segmentation which simply removes the background of the image, are just some of the possible ways to gather data to measure the gait variables.

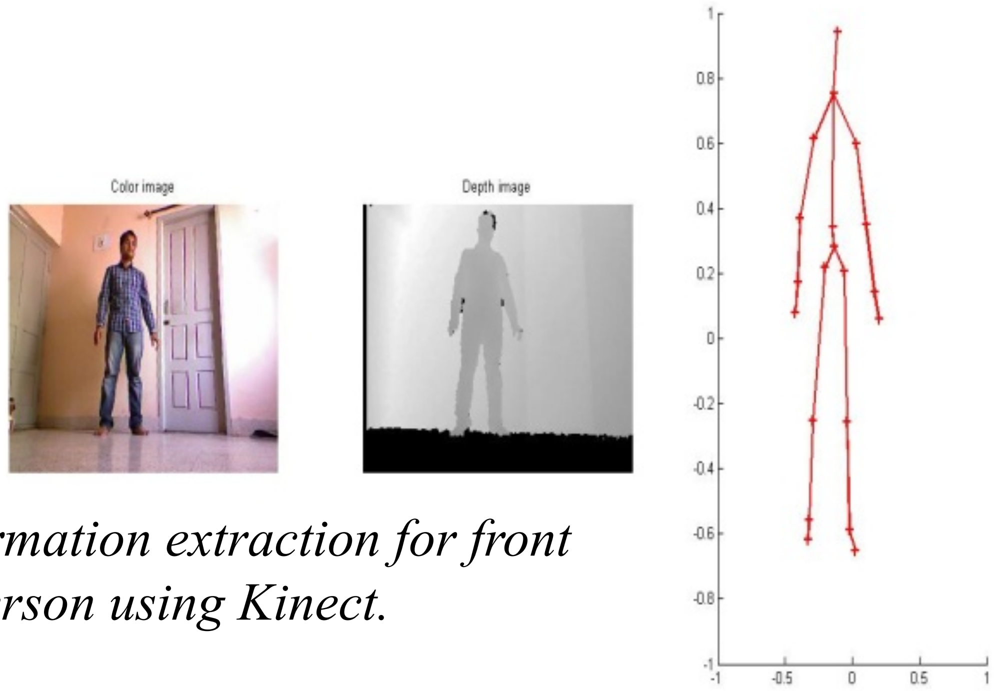
Depth measurement, also called range imaging: Time-of-Flight, Camera triangulation, Laser range scanner.



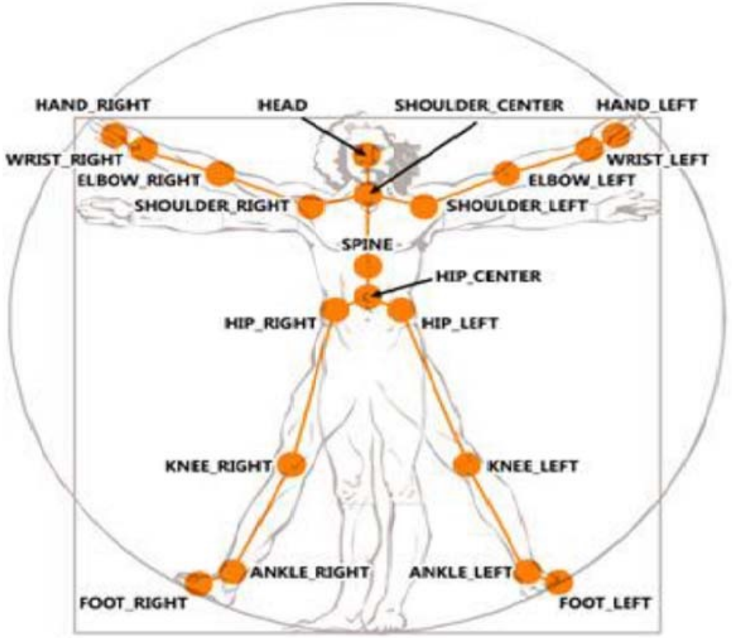
Infrared Thermography

Using Kinect

For each frame , the positions of 20 joint points are estimated and collected.
Each joint point has a unique index value and each joint position is expressed in (x,y,z) coordinates. The x, y and z axes are the body axes of the depth sensor, from the skeleton tracked by the Kinect first it extracts the values of joint positions, since each joint position is expressed in 3 coordinates and the detected skeleton has of 20 joints, so, the feature vector has 60 dimensions.

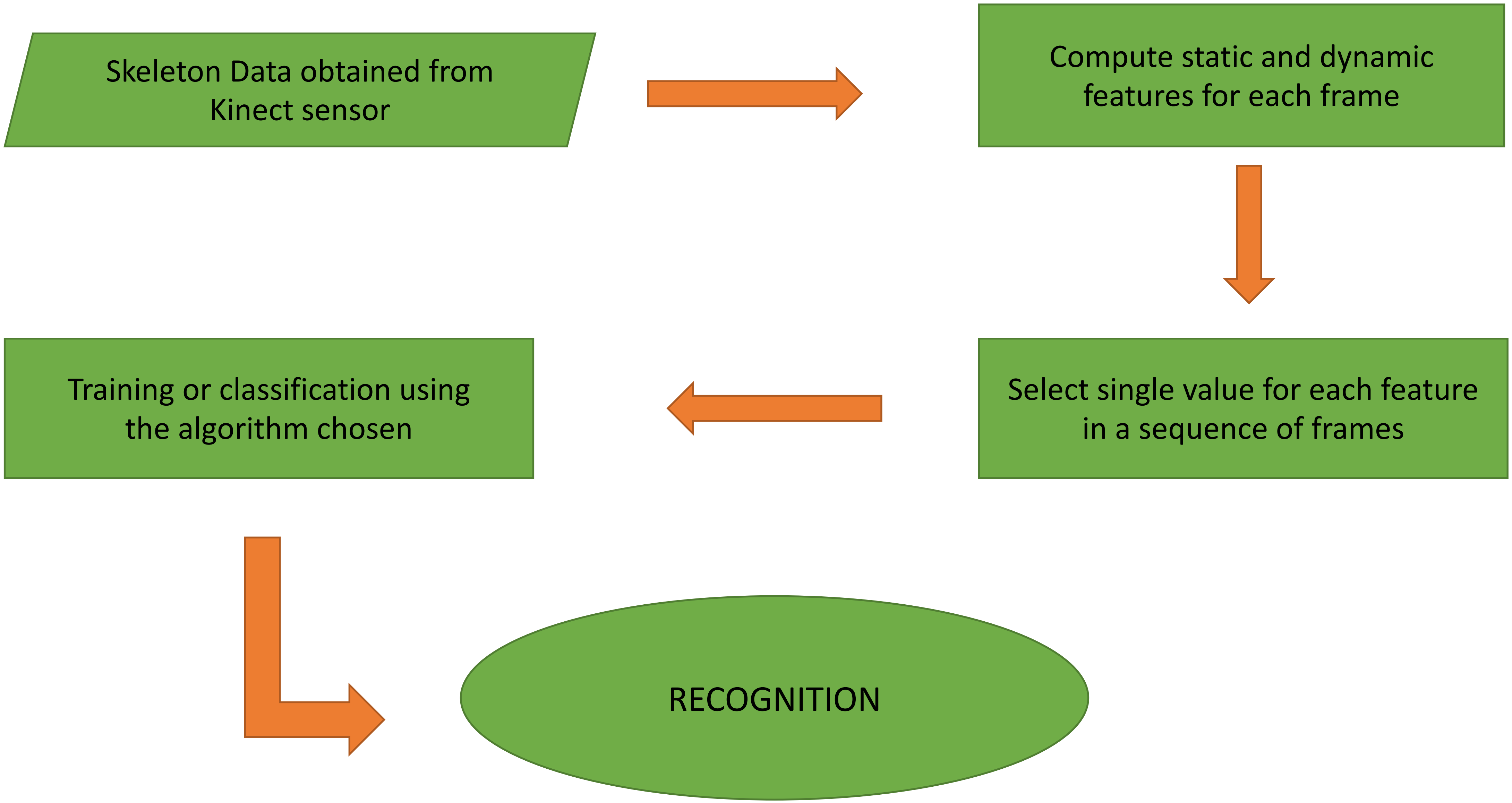


Skeleton information extraction for front view of the person using Kinect.



Human skeleton joints as reference.

Using Kinect

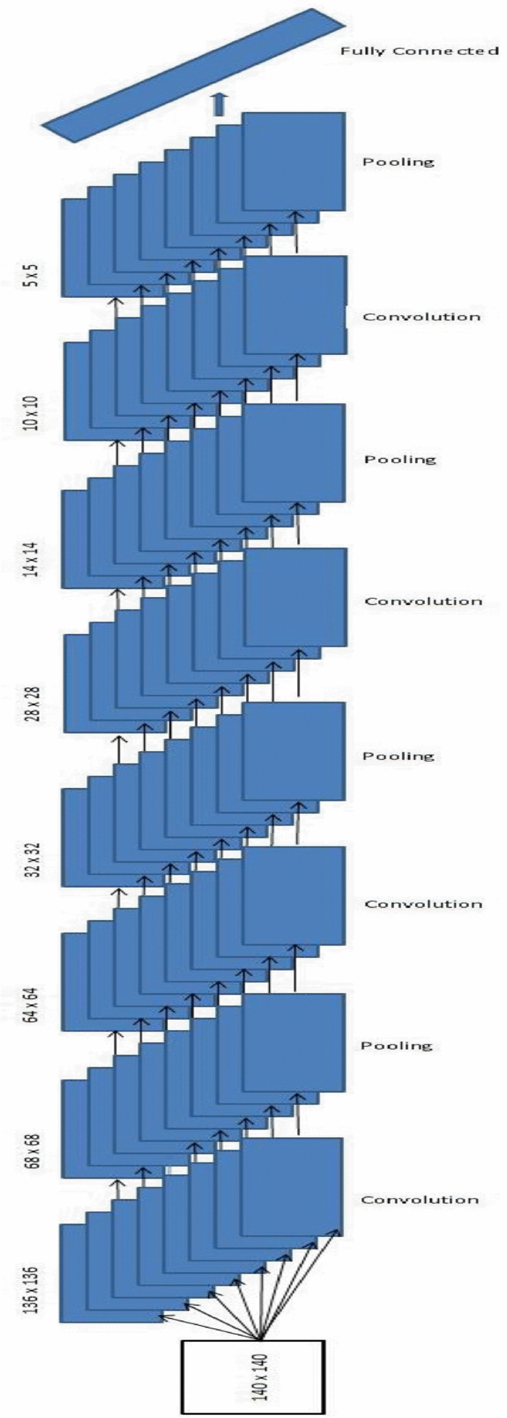


Let's improve with CNN's

Example: Improved Gait Recognition based on Specialized Deep Convolutional Neural Networks (Munif Alotaibi and Ausif Mahmood)

Highlights:

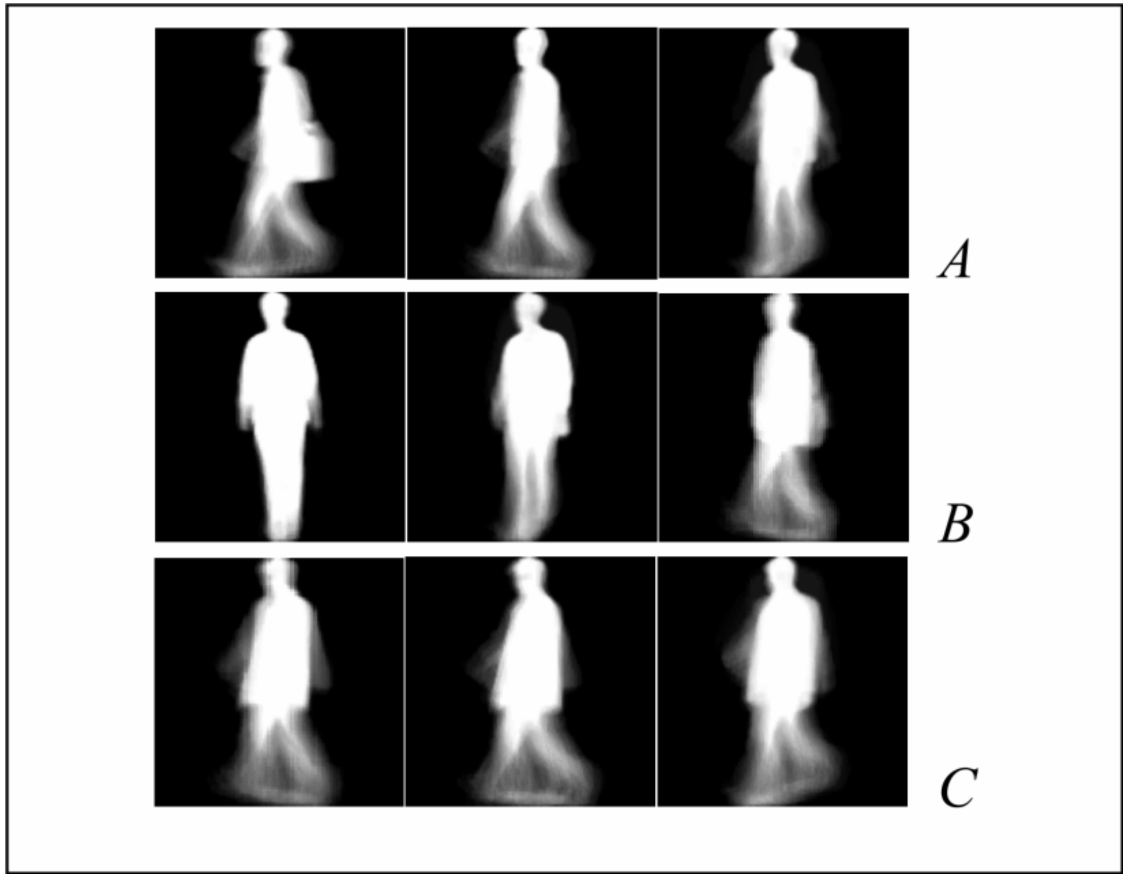
- Eight layers: four convolutional layers and four subsampling (pooling) layers.
- Each of these layers has eight feature maps: There are eight convolutional feature maps that are randomly initialized in every convolutional layer, and eight subsampling feature maps in each subsampling layer.
- Training: back-propagation learning algorithm .
- Optimization:Stochastic gradient descent with 1000 epochs.
- Input data: normalized by dividing each pixel value by 255.
- Learning rate: 0.0005 is used for all layers.



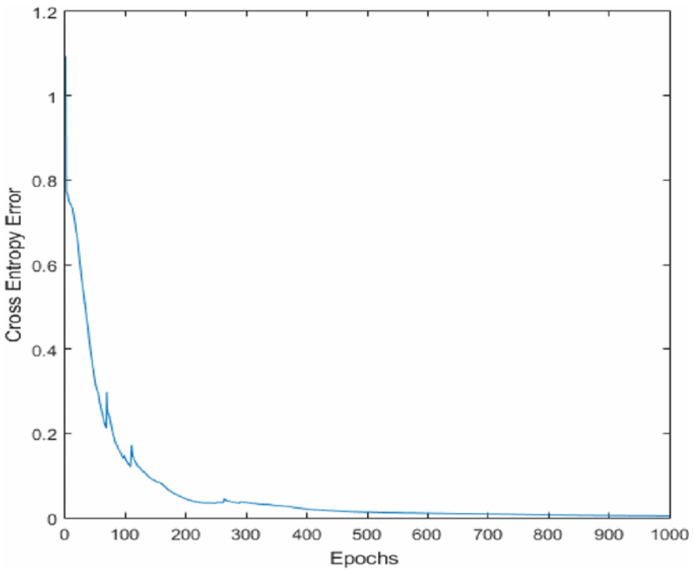
Let's improve with CNN's

Example: Improved Gait Recognition based on Specialized Deep Convolutional Neural Networks (Munif Alotaibi and Ausif Mahmood)

As input they use IR frames of the CASIA-B large gait dataset, A) in normal condition, B) in carrying condition, C) in clothing condition.

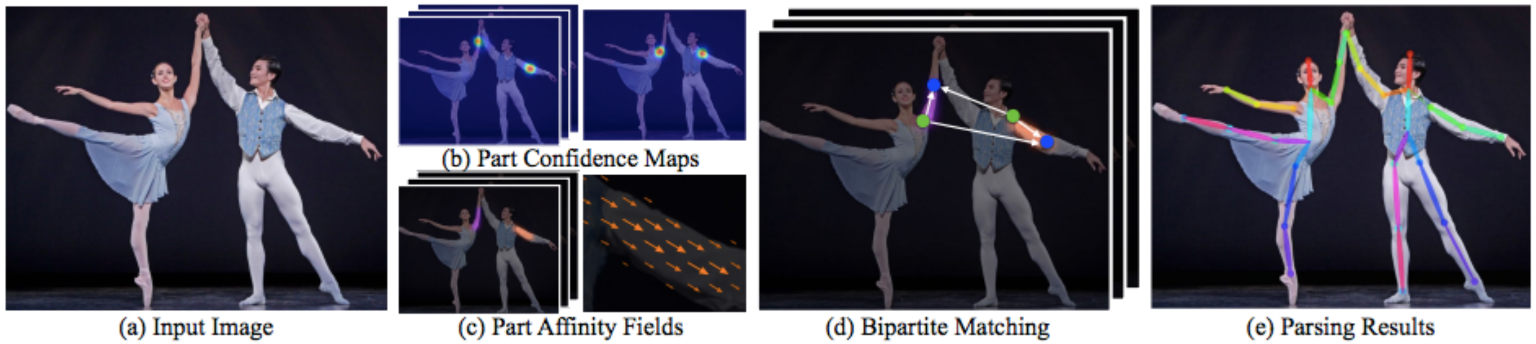


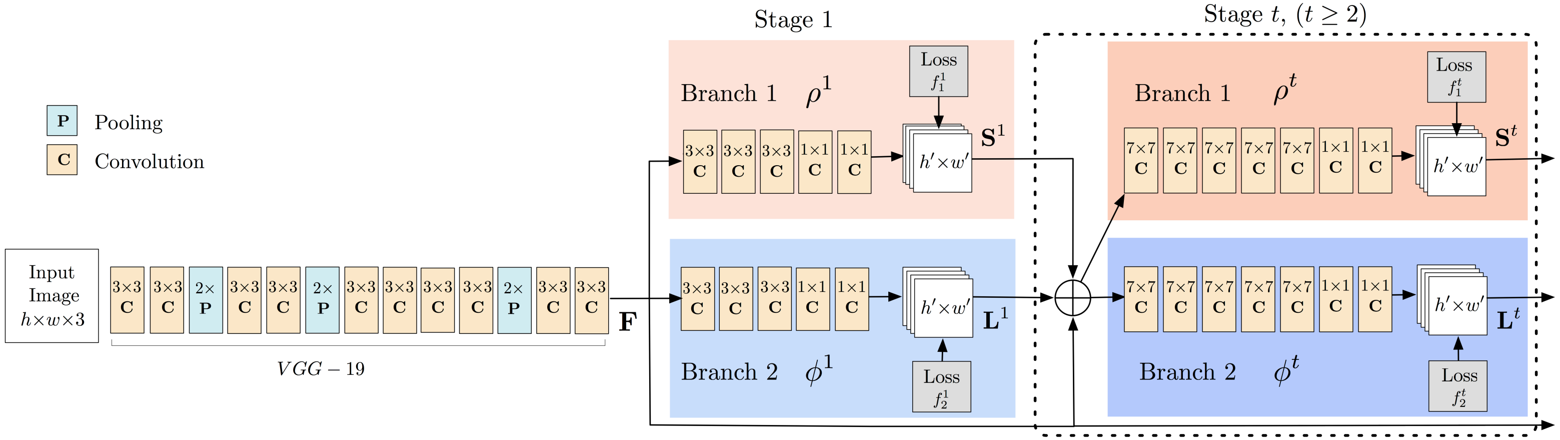
Results in error:



Let's improve with CNN’s: skeleton information

Example: Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields (Zhe Cao, Tomas Simon, Shih-En Wei, Yaser Sheikh)(2017)





The method takes the entire image as the input for a two-branch CNN to jointly predict confidence maps for body part detection, shown in (b), and part affinity fields for parts association, shown in (c). The parsing step performs a set of bipartite matchings to associate body parts candidates (d). We finally assemble them into full body poses for all people in the image (e).

Let's improve with CNN’s: skeleton information

Real-time Multi-Person 2D Pose Estimation Using Part Affinity Fields

Zhe Cao, Tomas Simon, Shih-En Wei, Yaser Sheikh
Carnegie Mellon University

THE PROJECT

The aim: Use the GOTCHA dataset to create/train a NN that recognize who is the user from gait and if the user is indoor or outdoor. https://gotchaproject.github.io/

THE PROJECT

How to do this:

- Extract frames from video, we don't need all the frames but samples of consecutive frames;
- Use *Real time Multi-Person 2D Pose Estimation Using Part Affinity Fields* to detect the skeleton of the subject in the frame, particularly his feature body points;
- Store the position/coordinates of consecutive frame feature points in an array to create the pattern array (the pattern array store informations about the subject movement variations in time).
- Create a NN that use as input the pattern array and give us *the user id* as output:

- Use a lot of pattern array samples to train the network;
- Try to reach the highest accuracy chosing the best loss function.

THE PROJECT

References:

About the topic:

- https://www.sciencedirect.com/topics/neuroscience/gait-analysis
- https://www.runnersneed.com/expert-advice/gear-guides/gait-analysis.html
- https://link.springer.com/chapter/10.1007/978-3-319-68533-5_1
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3958266/
- https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7275961&tag=1

Example of Keras code for skeleton:

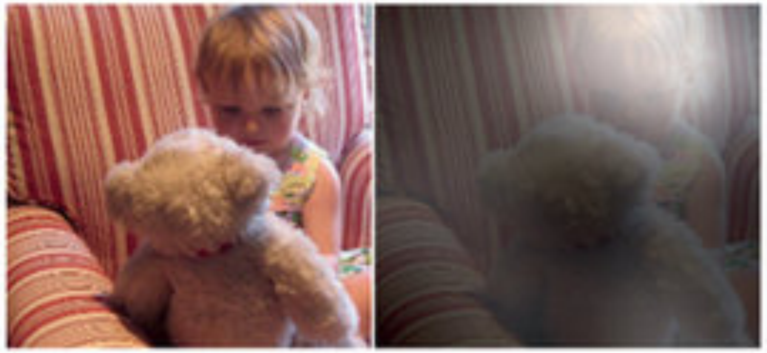
- https://github.com/michalfaber/keras_Realtime_Multi-Person_Pose_Estimation/blob/master/README.md

THE 2° PROJECT: IMAGE CAPTIONING

A woman is throwing a **frisbee** in a park.

A **dog** is standing on a hardwood floor.

A **stop** sign is on a road with a mountain in the background



A little **girl** sitting on a bed with a teddy bear.

A group of **people** sitting on a boat in the water.

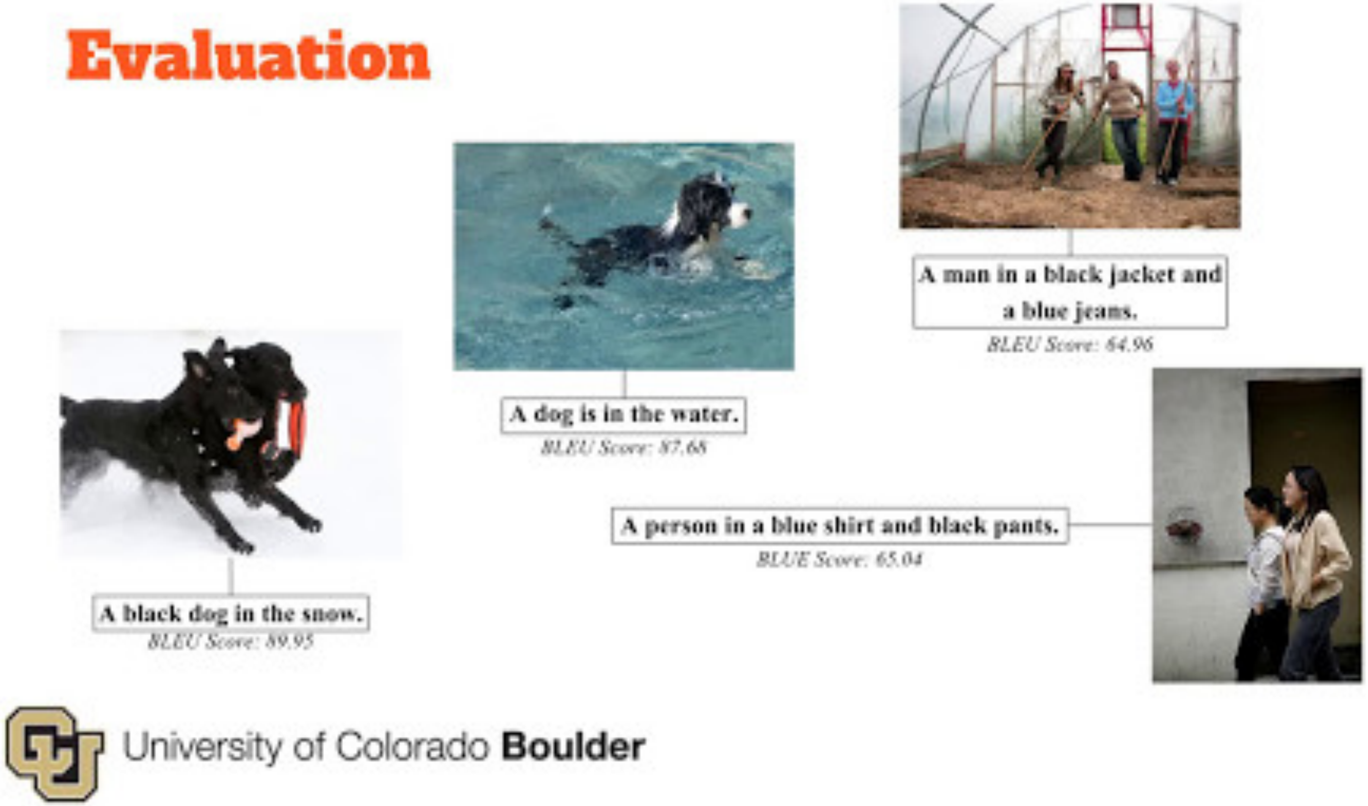
A giraffe standing in a forest with **trees** in the background.

THE 2° PROJECT:
IMAGE CAPTIONING

Image captioning is a fundamental task which requires semantic understanding of images and the ability of generating description sentences with proper and correct structure.

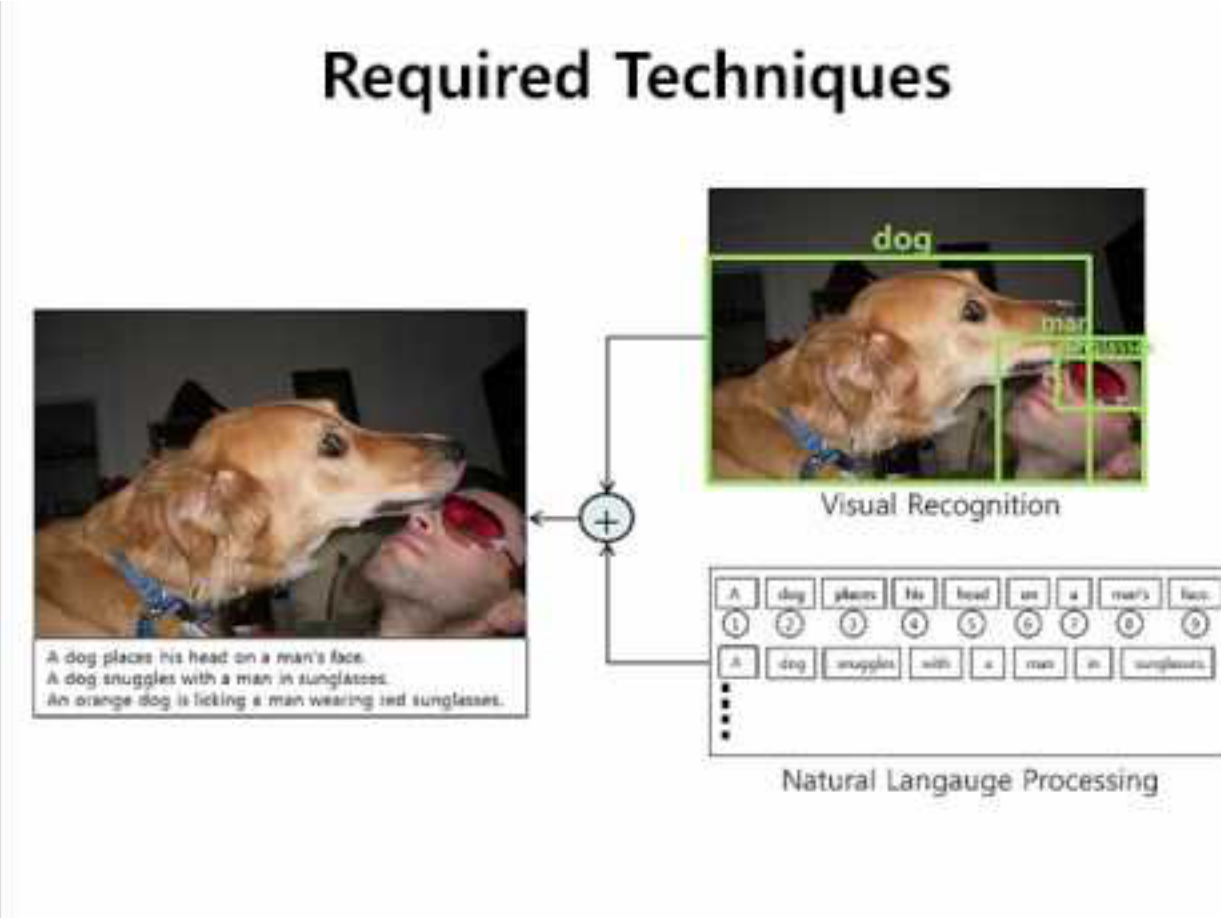
It involves the dual techniques from computer vision to understand the content of the image and a language model from the field of natural language processing to turn the understanding of the image into words in the right order. Image captioning has various applications such as recommendations in editing applications, usage in virtual assistants, for image indexing, for visually impaired persons, for social media, and several other natural language processing applications.

A STATE-OF-THE-ART EXAMPLE



https://www.youtube.com/watch?v=f2waevH1b6I

A STATE-OF-THE-ART EXAMPLE



https://www.youtube.com/watch?v=jYCLECwVo8g

A POPULAR DATASET

The Flickr30k dataset has become a standard benchmark for sentence-based image description.

https://www.kaggle.com/hsankesara/flickr-image-dataset

THE 2° PROJECT

The aim: Use the FLICKR dataset to create/train a NN that create the caption of images.

image_name	comment_number	comment
1000092795.jpg	0	Two young guys with shaggy hair look at their hands while hanging out in the yard .
1000092795.jpg	1	Two young , White males are outside near many bushes .
1000092795.jpg	2	Two men in green shirts are standing in a yard .
1000092795.jpg	3	A man in a blue shirt standing in a garden .
1000092795.jpg	4	Two friends enjoy time spent together .
10002456.jpg	0	Several men in hard hats are operating a giant pulley system .
10002456.jpg	1	Workers look down from up above on a piece of equipment .
10002456.jpg	2	Two men working on a machine wearing hard hats .
10002456.jpg	3	Four men on top of a tall structure .
10002456.jpg	4	Three men on a large rig .
1000268201.jpg	0	A child in a pink dress is climbing up a set of stairs in an entry way .
1000268201.jpg	1	A little girl in a pink dress going into a wooden cabin .
1000268201.jpg	2	A little girl climbing the stairs to her playhouse .
1000268201.jpg	3	A little girl climbing into a wooden playhouse
1000268201.jpg	4	A girl going into a wooden building .
1000344755.jpg	0	Someone in a blue shirt and hat is standing on stair and leaning against a window .
1000344755.jpg	1	A man in a blue shirt is standing on a ladder cleaning a window .
1000344755.jpg	2	A man on a ladder cleans the window of a tall building .
1000344755.jpg	3	man in blue shirt and jeans on ladder cleaning windows
1000344755.jpg	4	a man on a ladder cleans a window
1000366164.jpg	0	Two men , one in a gray shirt , one in a black shirt , standing near a stove .
1000366164.jpg	1	Two guy cooking and joking around with the camera .

THE 2° PROJECT

References:

About the topic:
- https://www.ripublication.com/ijaer18/ijaerv13n9_102.pdf
- **https://www.mdpi.com/2076-3417/9/10/2024/pdf**
- https://medium.com/mlreview/multi-modal-methods-image-captioning-from-translation-to-attention-895b6444256e

Example of code:
- https://github.com/DeepRNN/image_captioning