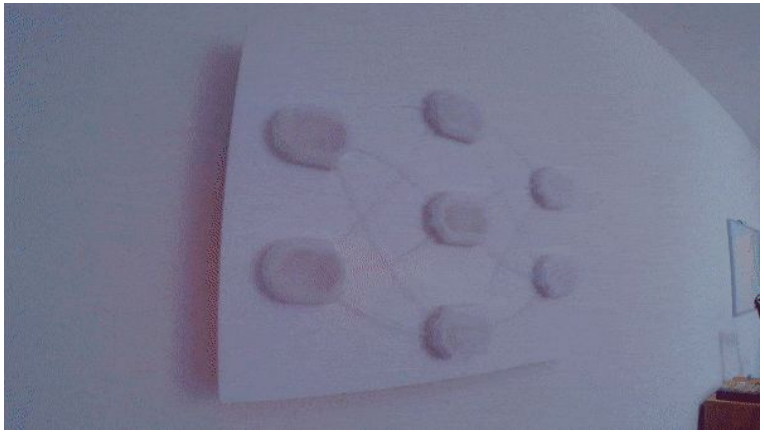
Shooting hoops with machine learning

@ZackAkil

Hola



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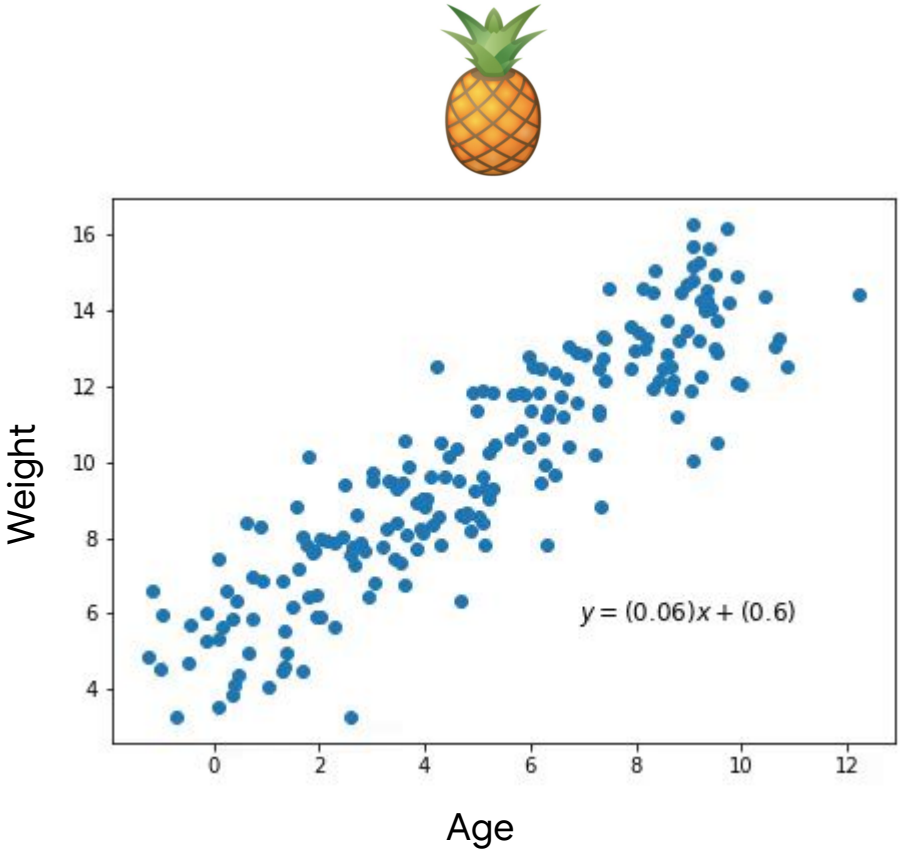

Linear Regression
(the line of best fit)

$$y = mx + c$$

Weight = (0.82)Age + 5.8

bit.ly/**zack-akil-line**

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> *If I can't be **good** at it,*
>
> *Can I look **cool** doing it?*

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@ZackAkil

@ZackAkil

@ZackAkil

```
if (pixel_colour == white)
```

bit.ly/**zack-akil-ghost**

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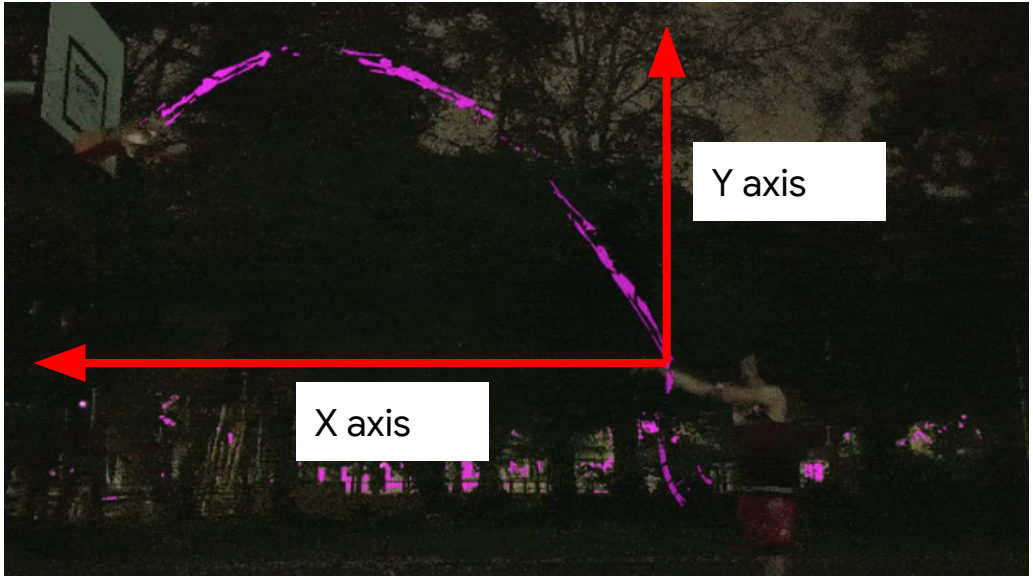
Looks like data



@ZackAkil

> *If I can't be **good** at it,*
>
> *Or look **cool** doing it,*
>
> *Can I do some **Machine Learning**?*

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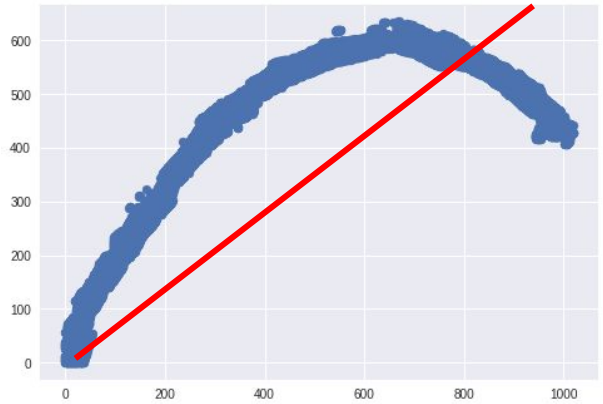
Standard Linear Regression (`y=mx+c`) 👎



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Trajectory

From Wikipedia, the free encyclopedia

For other uses, see Trajectory (disambiguation).
"Flightpath" redirects here. For other uses, see Flightpath (disambiguation).

A **trajectory** or **flight path** is the path that a object with mass in motion follows through space as a function of time. In classical mechanics, a trajectory is defined by Hamiltonian mechanics via canonical coordinates; hence, a complete trajectory is defined by position and momentum, simultaneously. Trajectory in quantum mechanics is not defined due to Heisenberg uncertainty principle that position and momentum can not be measured simultaneously.

In classical mechanics, the mass might be a projectile or a satellite.[1] For example, it can be an orbit—the path of a planet, an asteroid, or a comet as it travels around a central mass.

In control theory a trajectory is a time-ordered set of states of a dynamical system (see e.g. Poincaré map). In discrete mathematics, a trajectory is a sequence $(f^k(x))_{k\in\mathbb{N}}$ of values calculated by the iterated application of a mapping f to an element x of its source.

Physics of trajectories [edit]

The motion of the particle is described by the second-order differential equation

$$m\frac{\mathrm{d}^2\vec{x}(t)}{\mathrm{d}t^2} = -\nabla V(\vec{x}(t)) \text{ with } \vec{x} = (x, y, z).$$

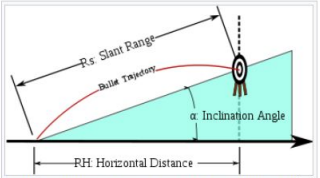
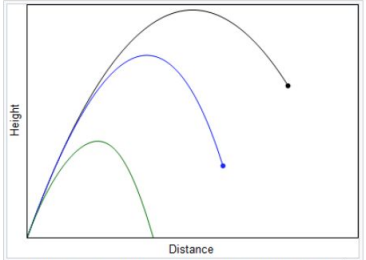


Illustration showing the trajectory of a bullet fired at an uphill target.

Examples [edit]

Uniform gravity, neither drag nor wind [edit]

The ideal case of motion of a projectile in a uniform gravitational field in the absence of other forces (such as air drag) was first investigated by Galileo Galilei. To neglect the action of the atmosphere in shaping a trajectory would have been considered a futile hypothesis by practical-minded investigators all through the Middle Ages in Europe. Nevertheless, by anticipating the existence of the vacuum, later to be demonstrated on Earth by his collaborator Evangelista Torricelli[citation needed], Galileo was able to initiate the future science of mechanics.[citation needed] In a near vacuum, as it turns out for instance on the Moon, his simplified parabolic trajectory proves essentially correct.



Trajectories of a mass thrown at an angle of 70°, with the same initial speed:
without drag
with Stokes drag
with Newton drag

In the analysis that follows, we derive the equation of motion of a projectile as measured from an inertial frame at rest with respect to the ground. Associated with the frame is a right-hand coordinate system with its origin at the point of launch of the projectile. The x-axis is tangent to the ground, and the $y$axis is perpendicular to it (parallel to the gravitational field lines). Let g be the acceleration of gravity. Relative to the flat terrain, let the initial horizontal speed be $v_h = v\cos(\theta)$ and the initial vertical speed be $v_v = v\sin(\theta)$. It will also be shown that the range is $2v_h v_v/g$, and the maximum altitude is $v_v^2/2g$. The maximum range for a given initial speed v is obtained when $v_h = v_v$, i.e. the initial angle is 45°. This range is v^2/g, and the maximum altitude at the maximum range is $v^2/(4g)$.

Derivation of the equation of motion [edit]

Assume the motion of the projectile is being measured from a free fall frame which happens to be at $(x,y) = (0,0)$ at $t = 0$. The equation of motion of the projectile in this frame (by the equivalence

$$y = \tan(\theta) \cdot x - \frac{gx^2}{2v^2\cos(^2\theta)}$$

bit.ly/**zack-akil-traj**

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bit.ly/**zack-akil-traj-tf**

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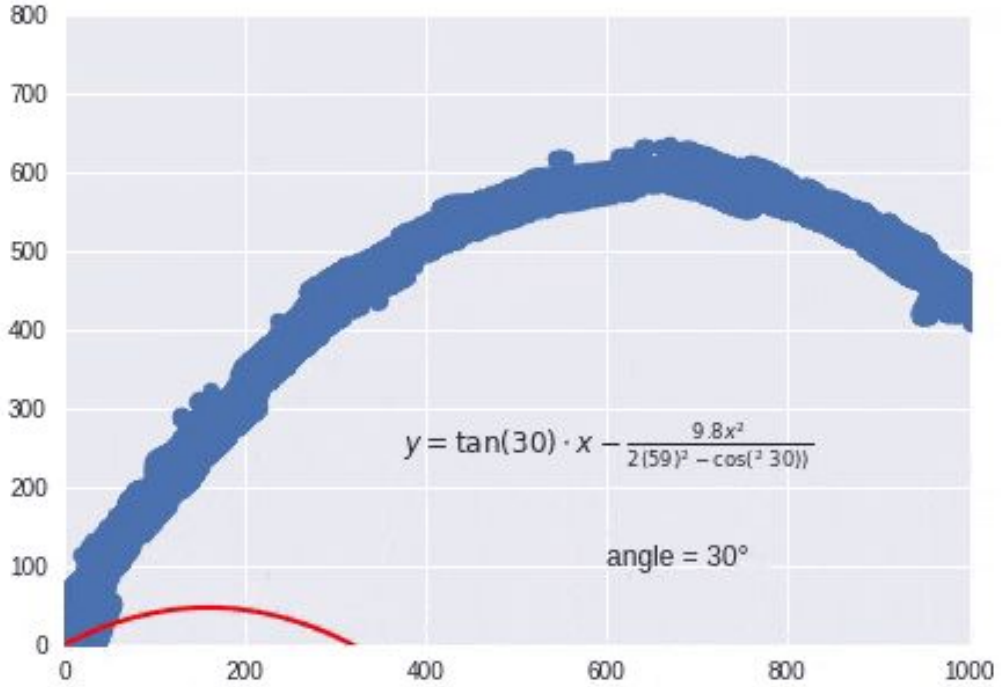
Fit equation to my shot



bit.ly/**zack-akil-traj-gif**

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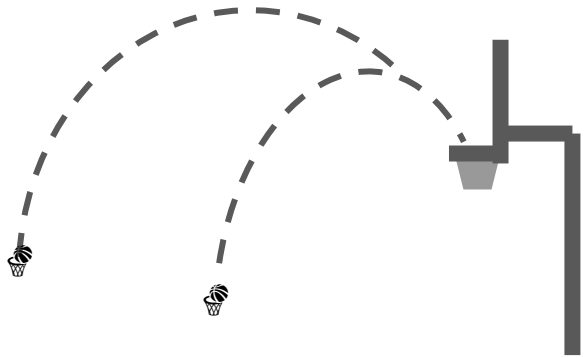
Consistency is key



“Your technique shouldn’t change,
the only thing that changes is the power”

- **Anita Hoops-McGee**

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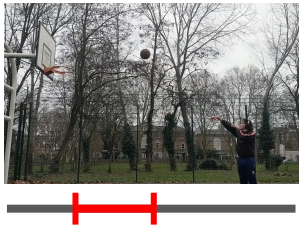
Shot analyse in 6 steps

Record shot

10 minutes

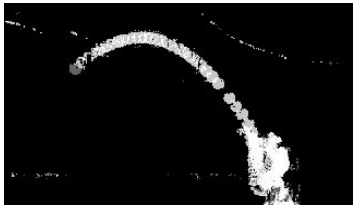
Go home

5 minutes (manual)



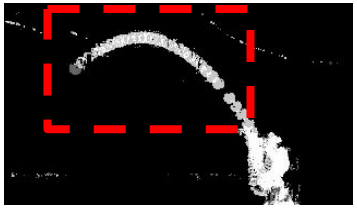
Trim video

< 1 second (automatic)



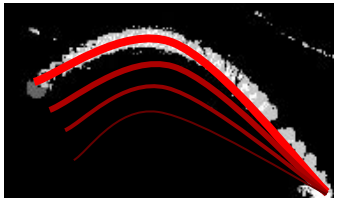
Apply pre-processing

5 minutes (manual)



Crop shot

1 second (automatic)



Run model

Your shot angle was 62°

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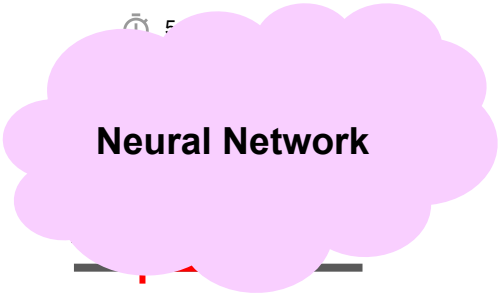
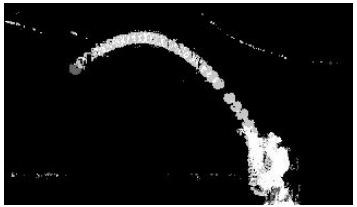
Shot analyse in 6 steps

Record shot

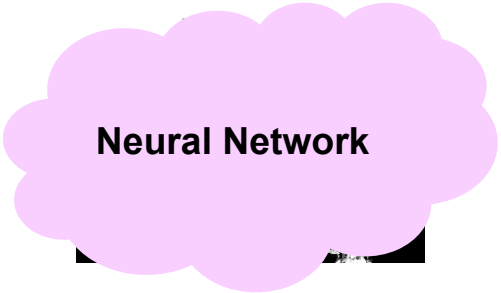


Trim video

< 1 second (automatic)

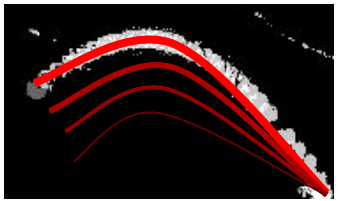


Apply pre-processing



Crop shot

1 second (automatic)



Run model

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Auto trimming model

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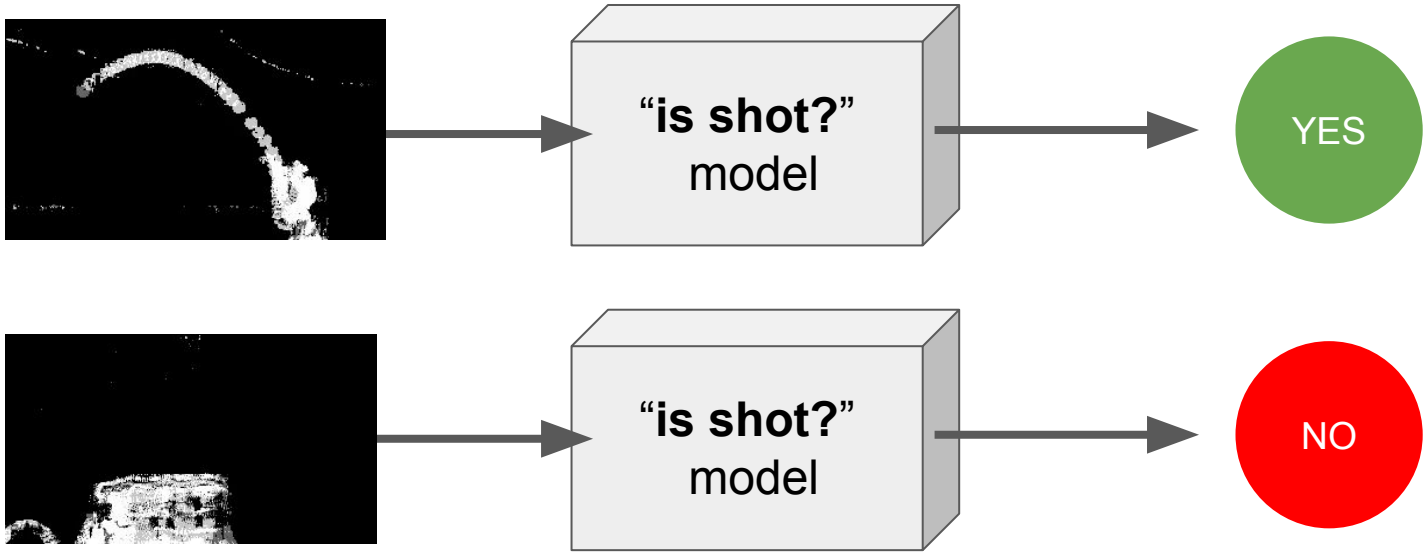
Auto-trimming model

Binary Classification Model
("yes" or "no" model)



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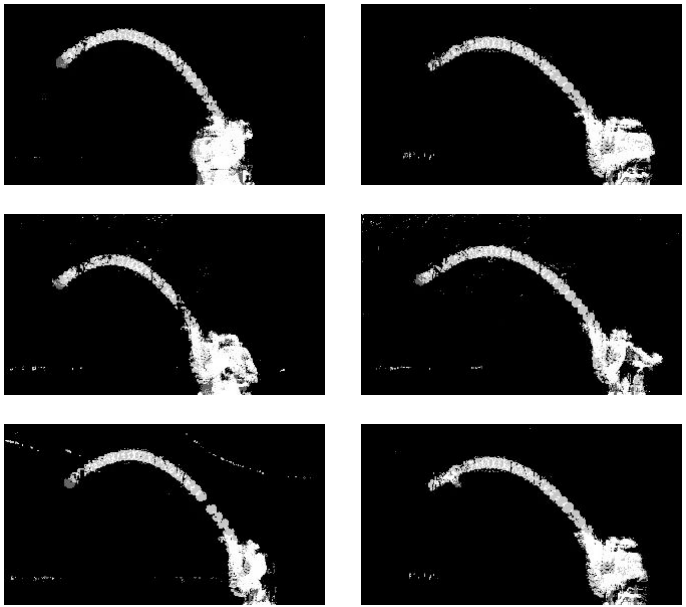
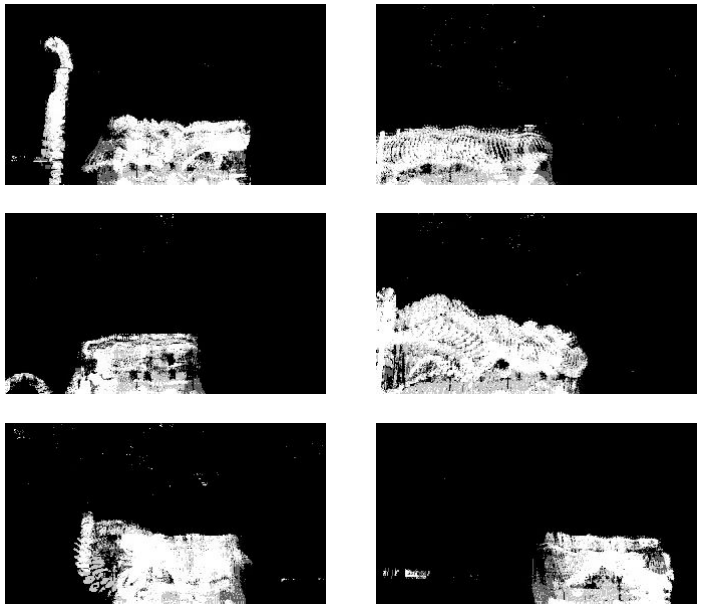
TRUE (yes)



FALSE (no)



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“is shot?” model

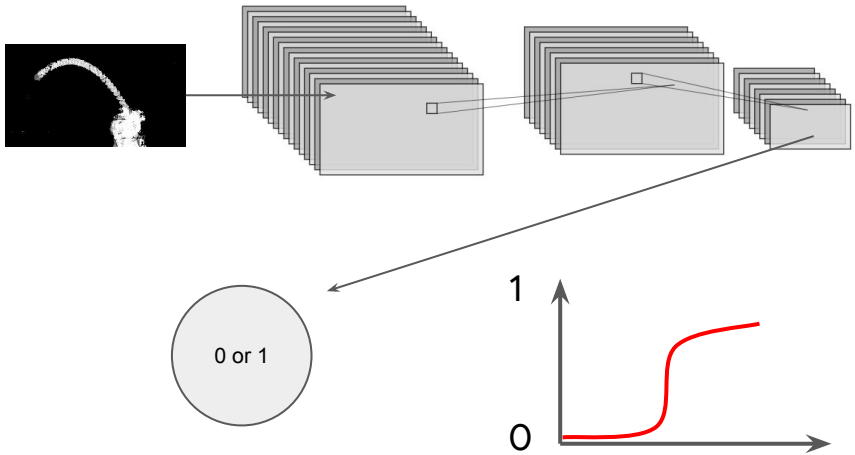
Convolutional Neural Network (CNN)
(Good at image based tasks)

Keras

```
model = Sequential()

model.add(Conv2D(4, kernel_size=(3, 3),
                 activation='relu',
                 input_shape=input_shape))

model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.5))
model.add(Flatten())
model.add(Dense(8, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(1, activation='sigmoid'))
```



bit.ly/**zack-akil-did-i-shoot-code**

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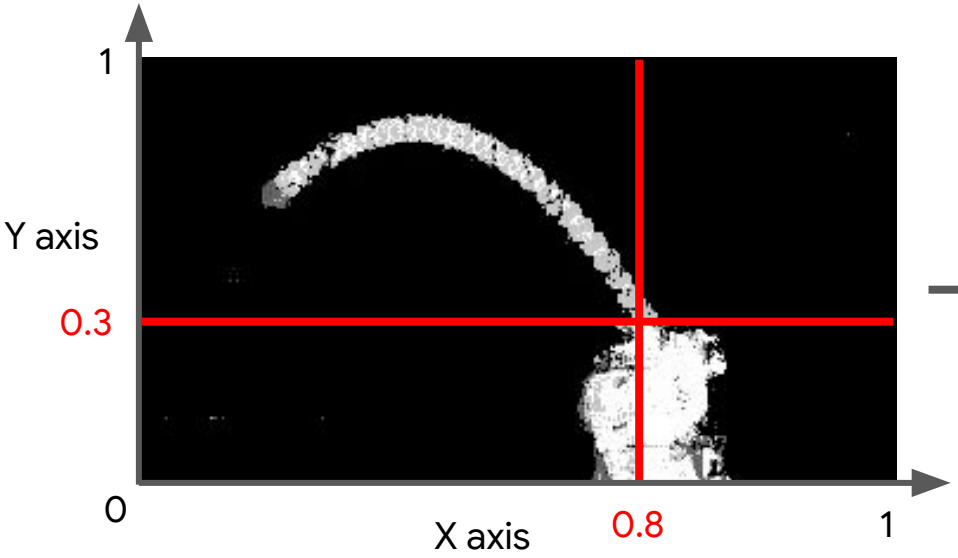
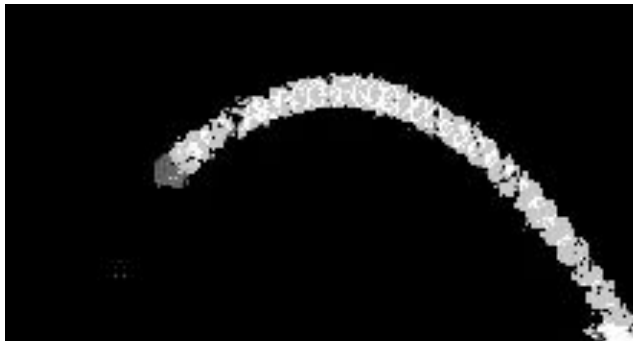
Shot demo
bit.ly/zack-akil-hoops-shot-demo

Where to crop the image from?





Crop from (**0.8**, **0.3**)

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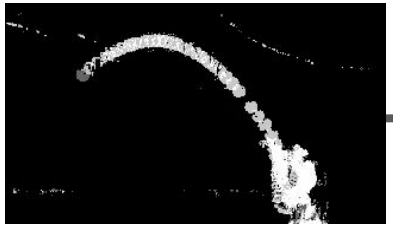
Auto-cropping model

Multi Target Regression Model
(predicting multiple numbers)

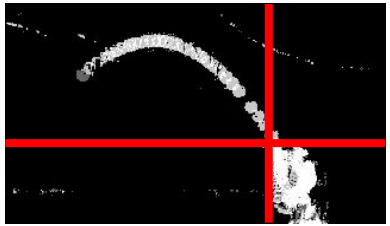


“**Where shot?**”
model

0.78

0.35

0.35



0.78

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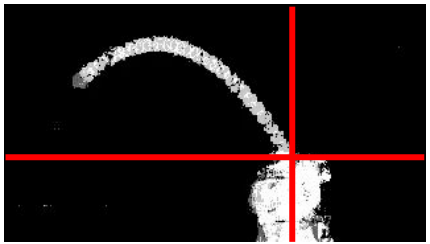
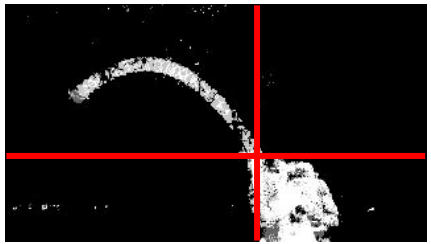
Where to crop from?

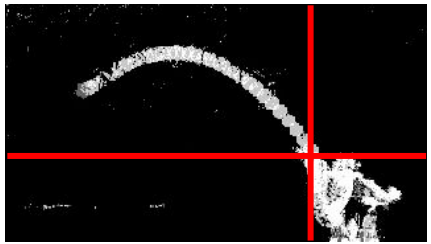
(0.8, 0.3)



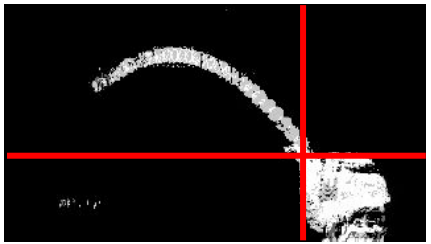
(0.76, 0.3)



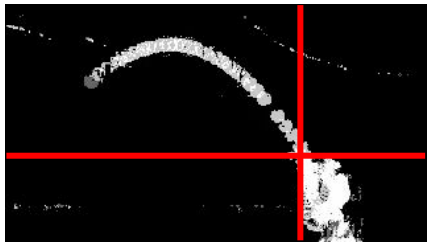
(0.66, 0.4)



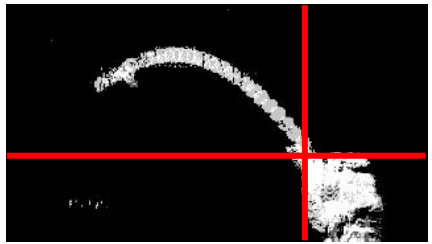
(0.7, 0.35)



(0.62, 0.41)



(0.76, 0.31)



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“Where shot?” model

Keras

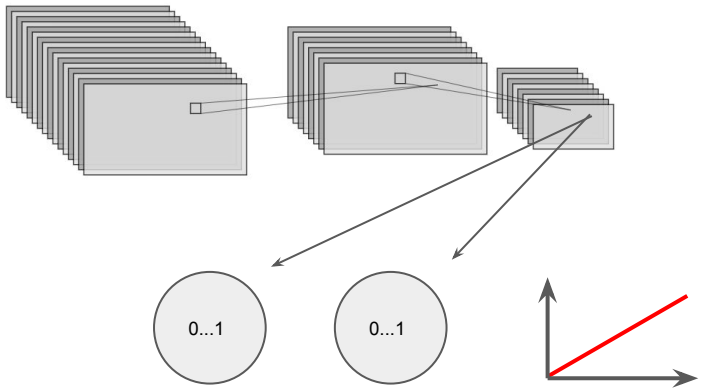
```
model = Sequential()

model.add(Conv2D(16, kernel_size=(3, 3),
                 activation='relu',
                 input_shape=input_shape))

model.add(Conv2D(8, (3, 3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.5))
model.add(Flatten())
model.add(Dense(16, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(2, activation='linear'))
```

Convolutional Neural Network (CNN)

(Good at image based tasks)



bit.ly/**zack-akil-where-i-shoot-code**

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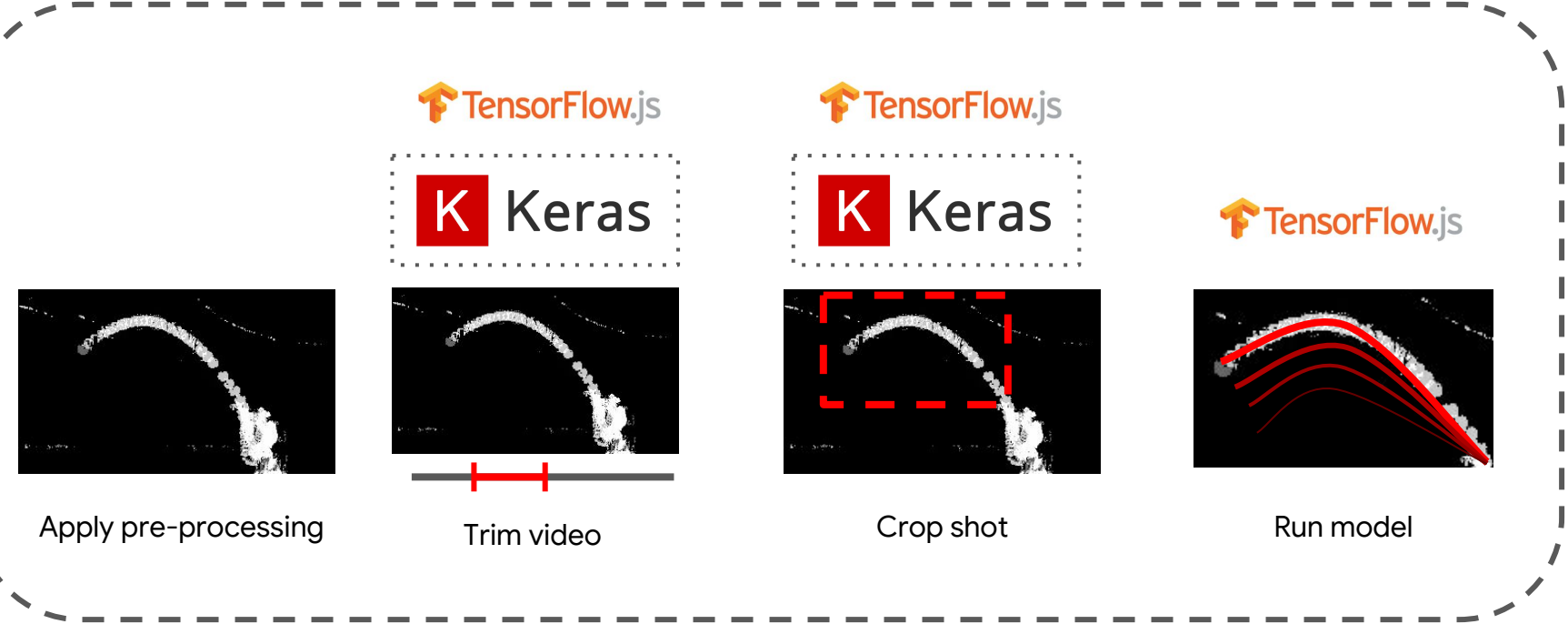
Shot Where demo
bit.ly/zack-akil-hoops-where-demo

All together now!



Inside a webpage

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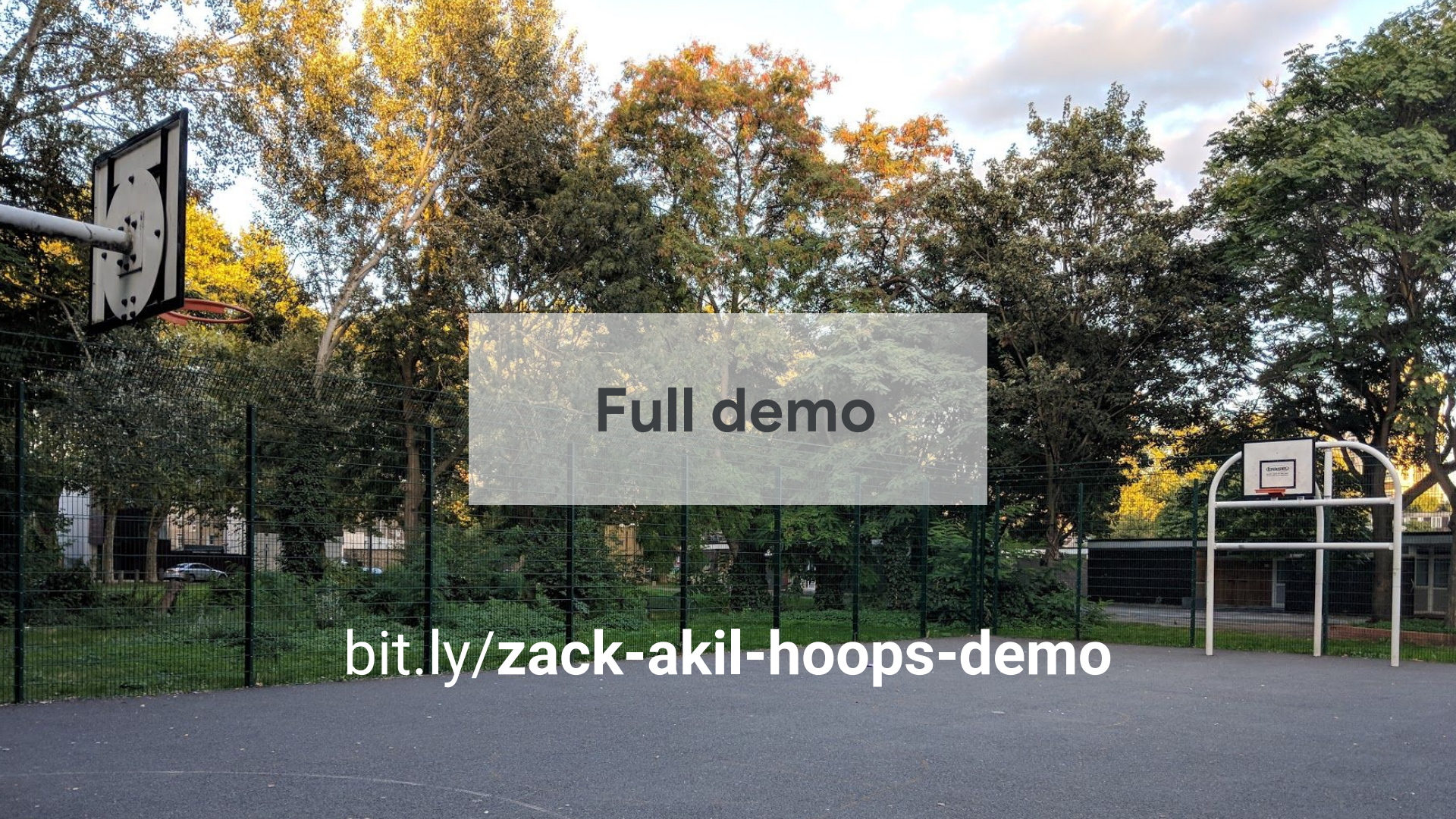
Full demo
bit.ly/zack-akil-hoops-demo


bit.ly/zack-akil-hoops
Gracias!
@ZackAkil