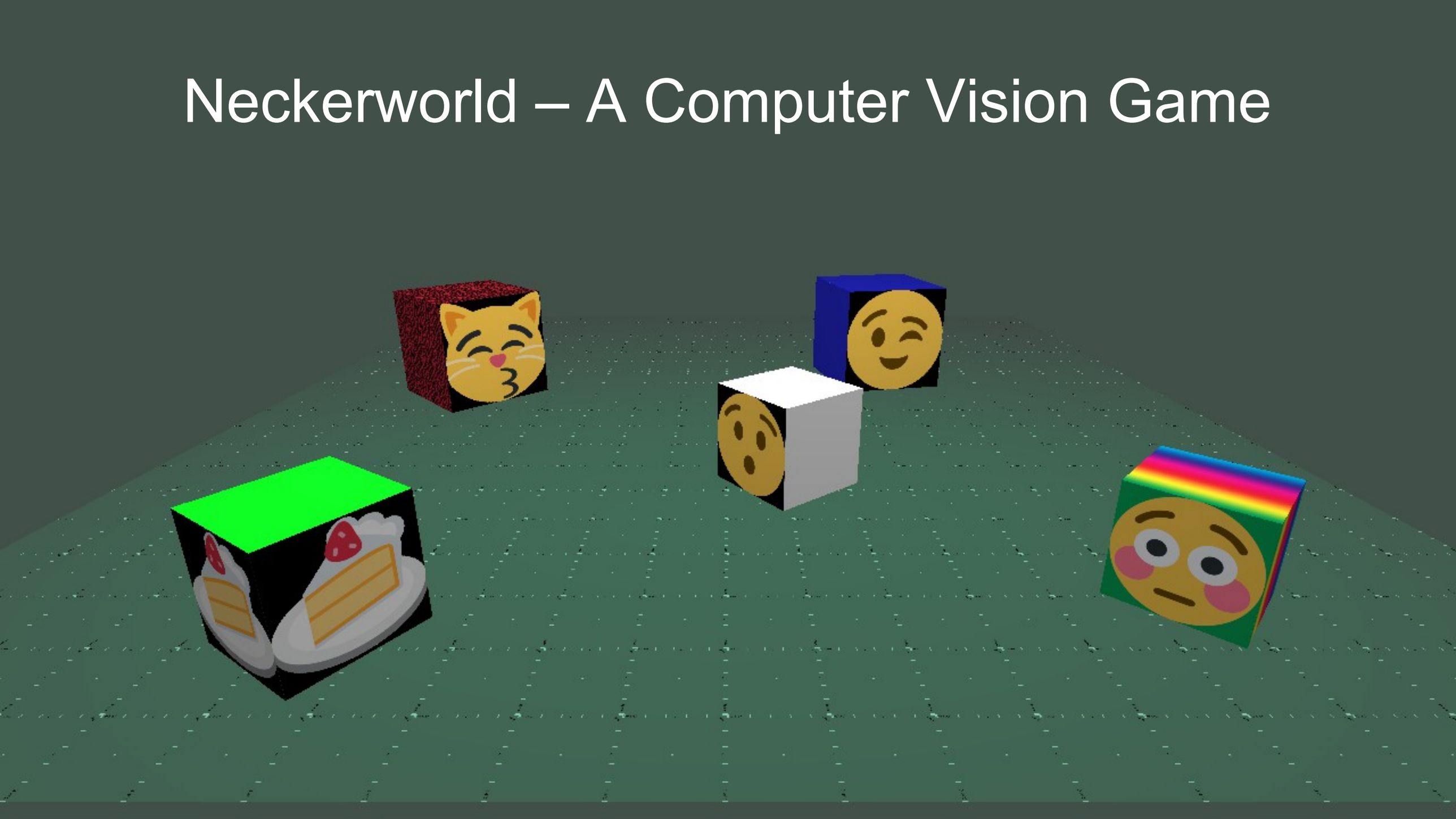
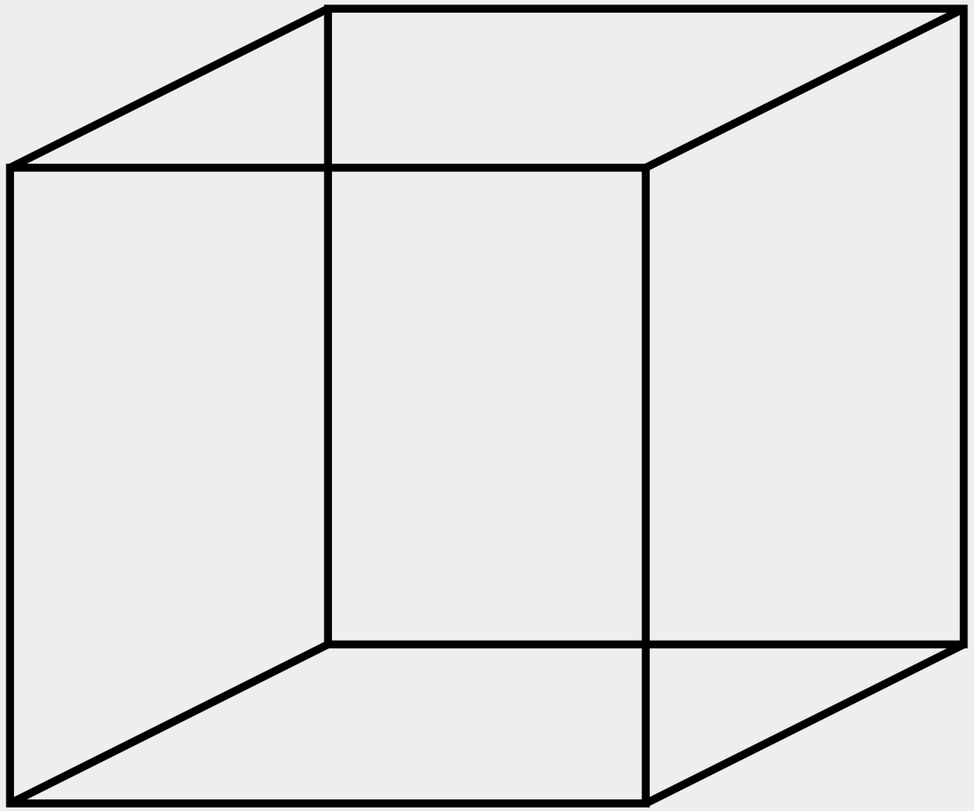
Neckerworld – A Computer Vision Game

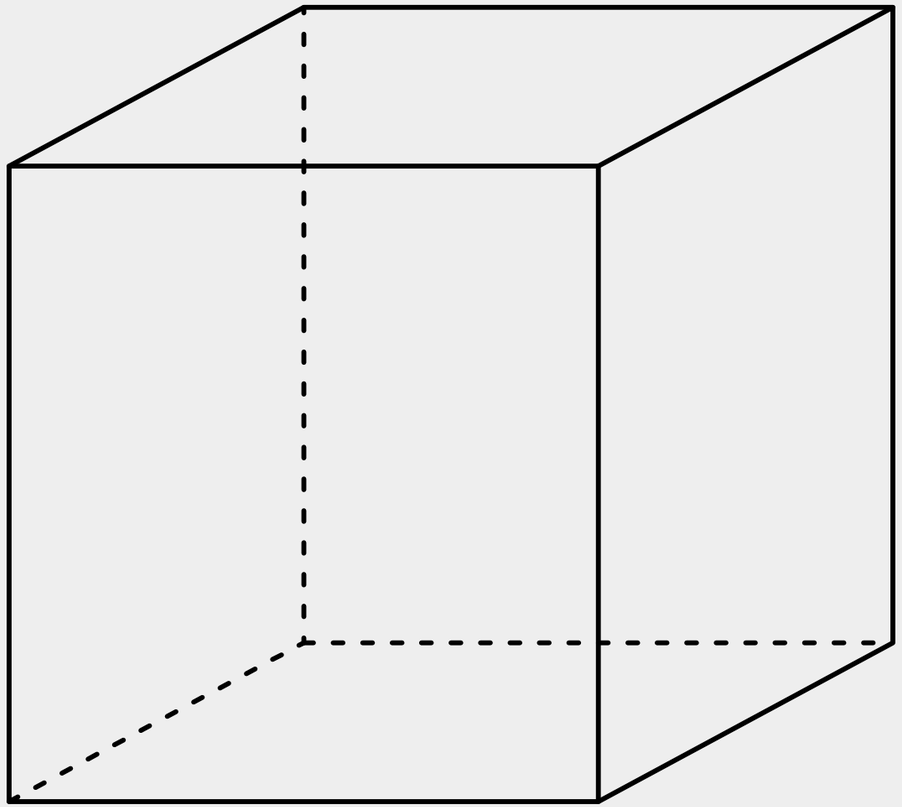


The Necker Cube Illusion



By BenFrantzDale - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=2040007

The Necker Cube Illusion



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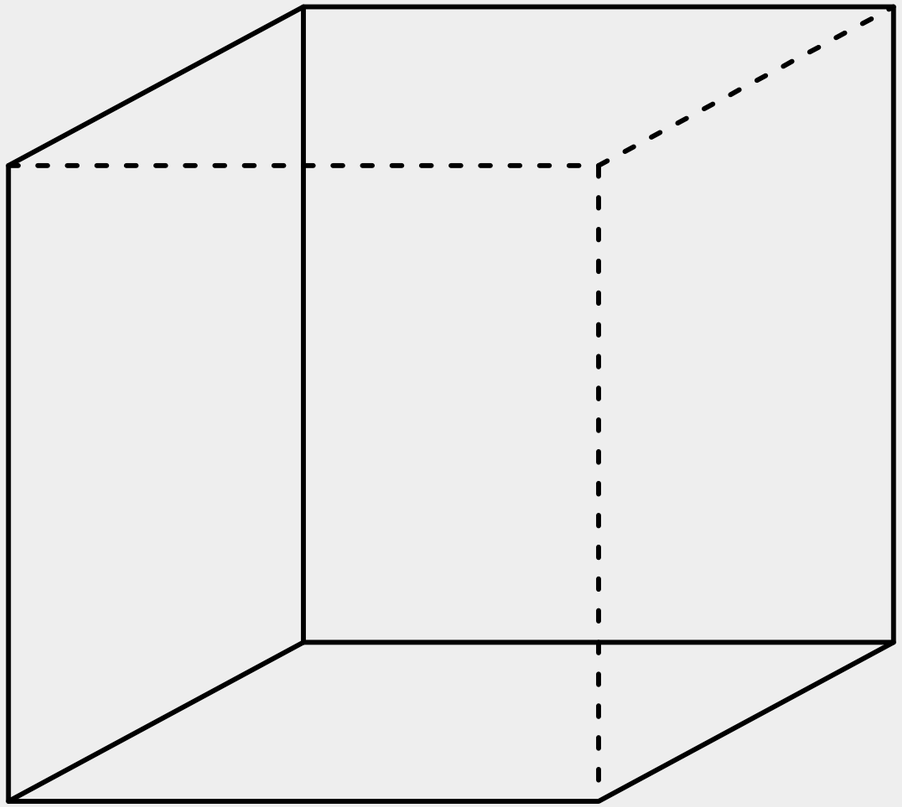
The Necker Cube Illusion



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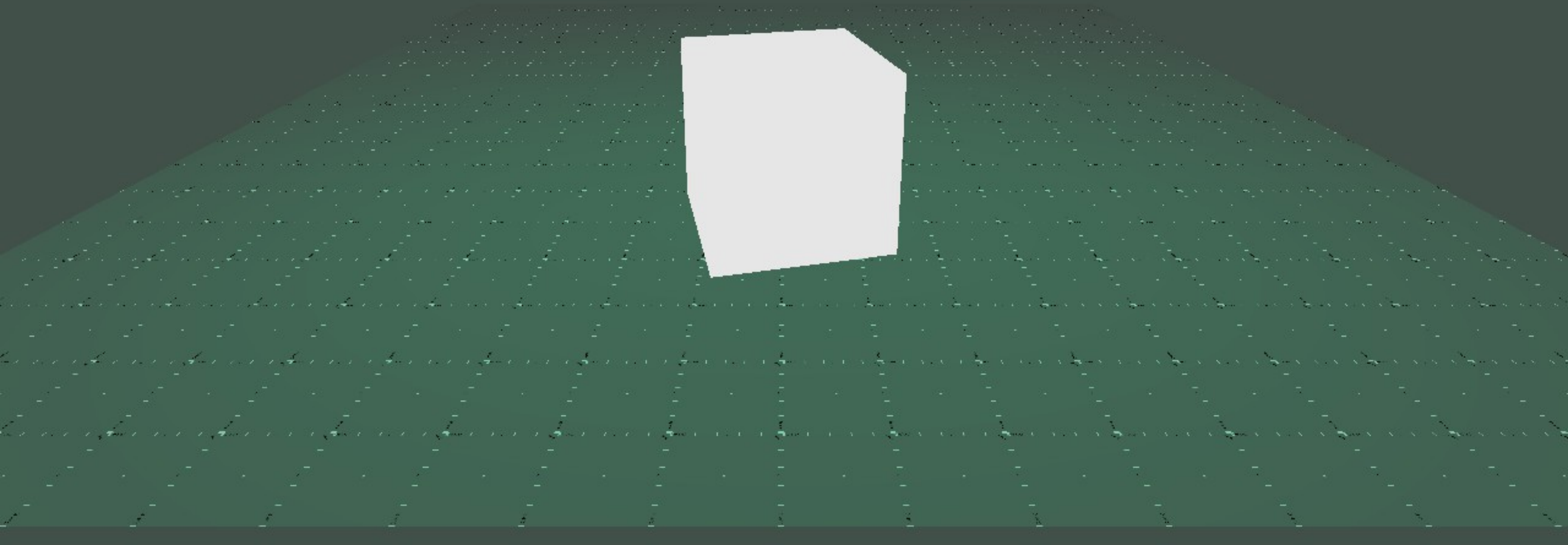
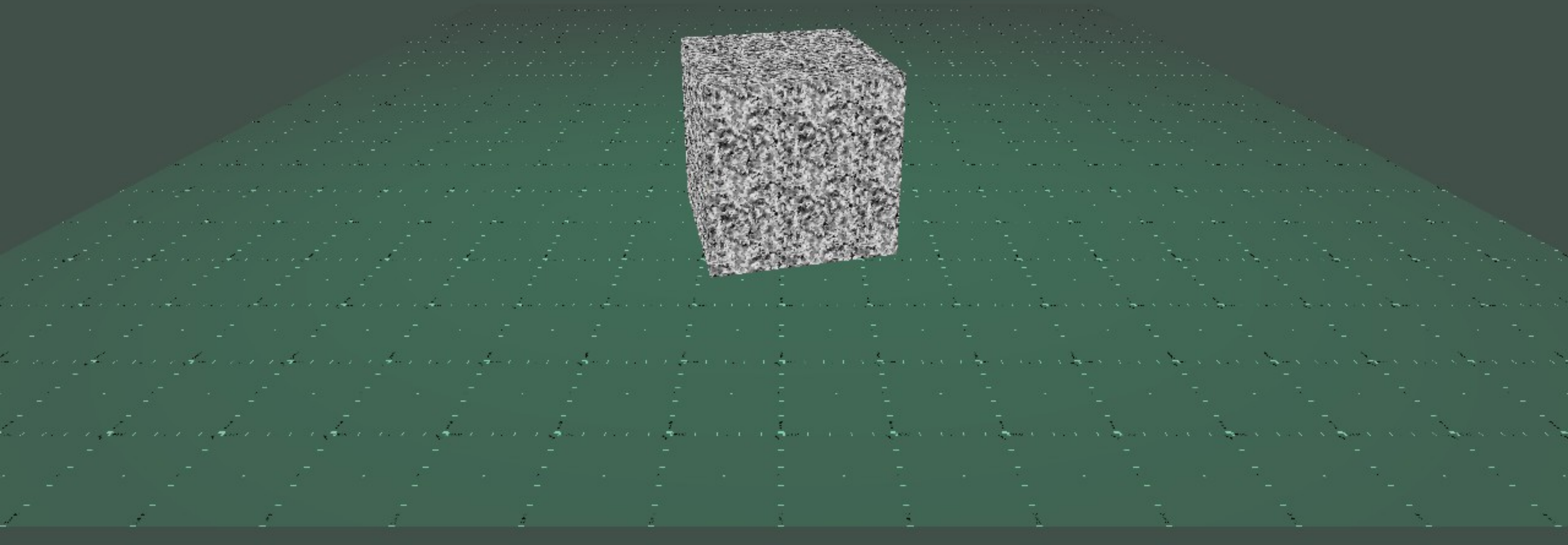
The Cube – A Basis for Studies of Visual Perception

Colored Surface Only



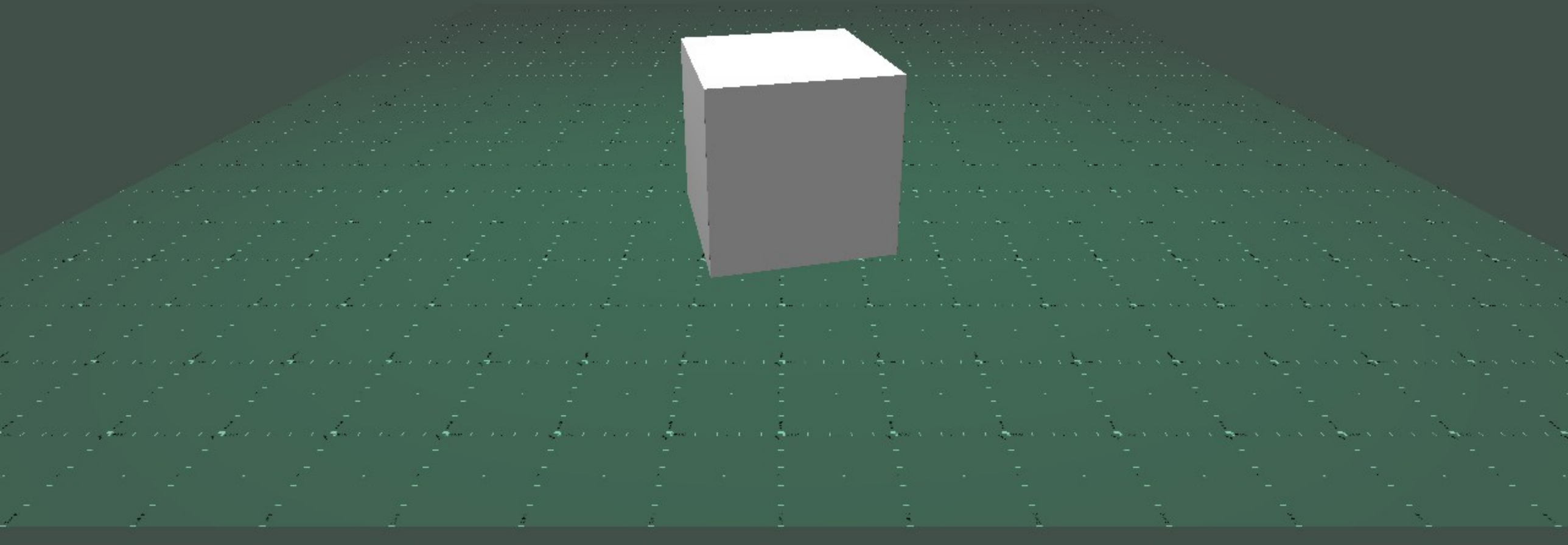
The Cube – A Basis for Studies of Visual Perception

Textured Surfaces



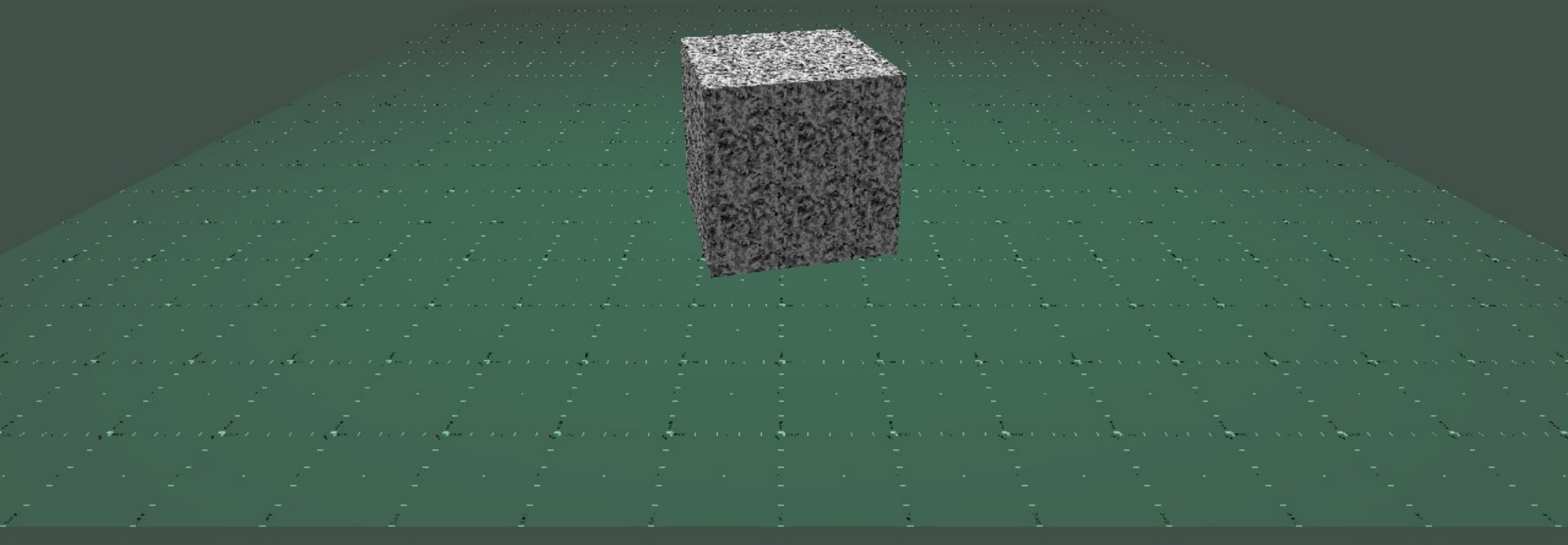
The Cube – A Basis for Studies of Visual Perception

Shaded Surfaces



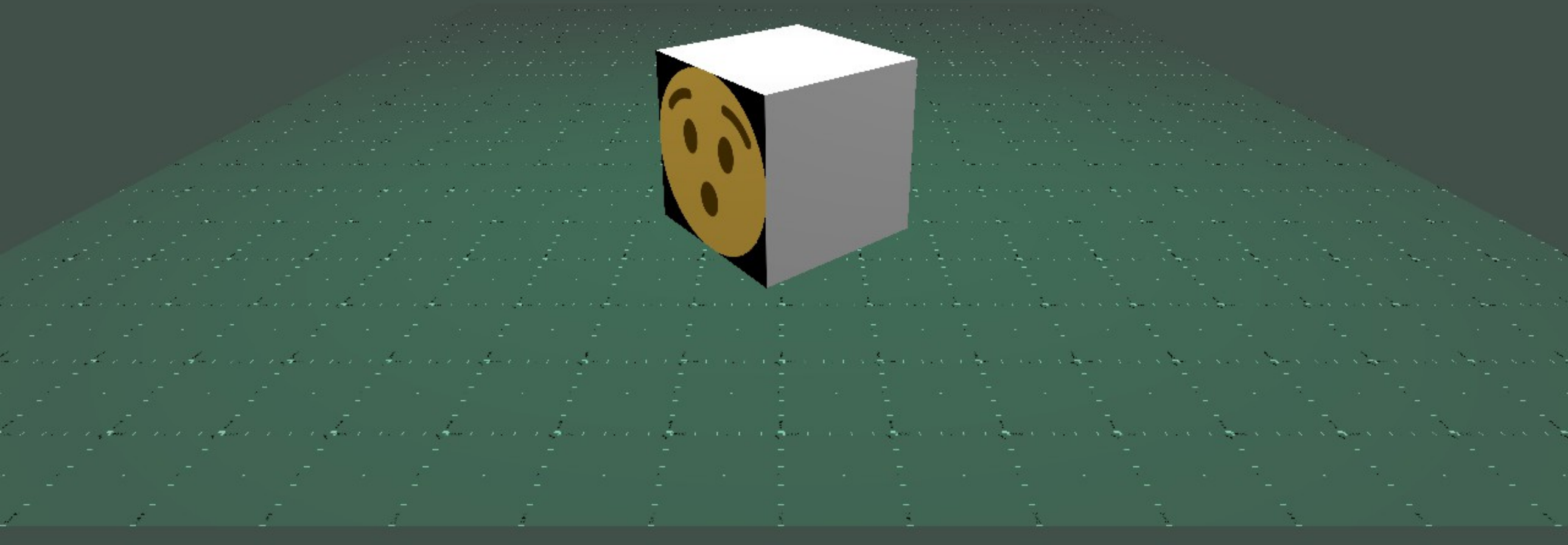
The Cube – A Basis for Studies of Visual Perception

Shaded Textured Surfaces

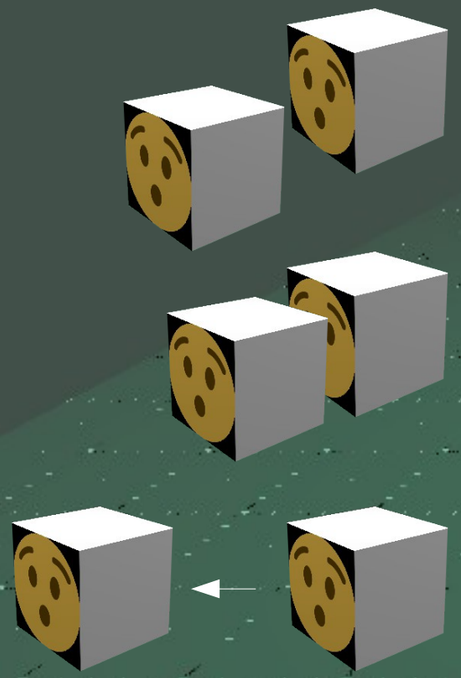


The Cube – A Basis for Studies of Visual Perception

Shaded Surfaces with Features



The Cube – A Basis for Studies of Visual Perception



Studies and experiments in size constancy

Rules about occlusion of image objects

Perceived motion

Neckerworld – A Computer Vision Game

Visual Systems are very different

They are uniquely engineered to serve the needs of the organism

They have evolved over 100's of millions of years

The human visual system serves humans well,
but not zebras, owls, rats, bees, or spiders

Neckerworld – A Computer Vision Game

Three guiding principals of the human visual system:

Find something to eat

Don't get eaten

Find a mate

Neckerworld – Game Design

All players and resources in the game are cubes

The cube players are guided solely
through autonomous computer vision programs

No human manual control or input permitted

Requires competent programs to do object detection
and playing field knowledge representation

Neckerworld – Game Design

Game points are scored through three activities:

Finding and reaching food resources

Killing off predators

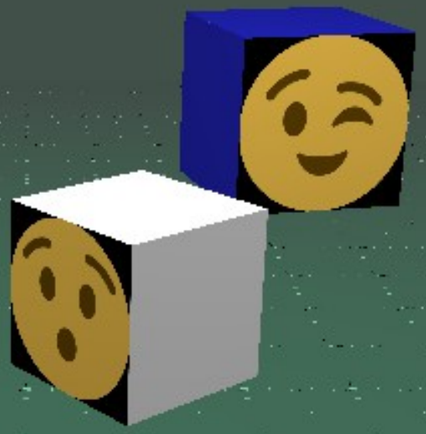
Mating and having child cubes

Neckerworld – Game Technology

Neckerworld – Game Players

Predators

Males

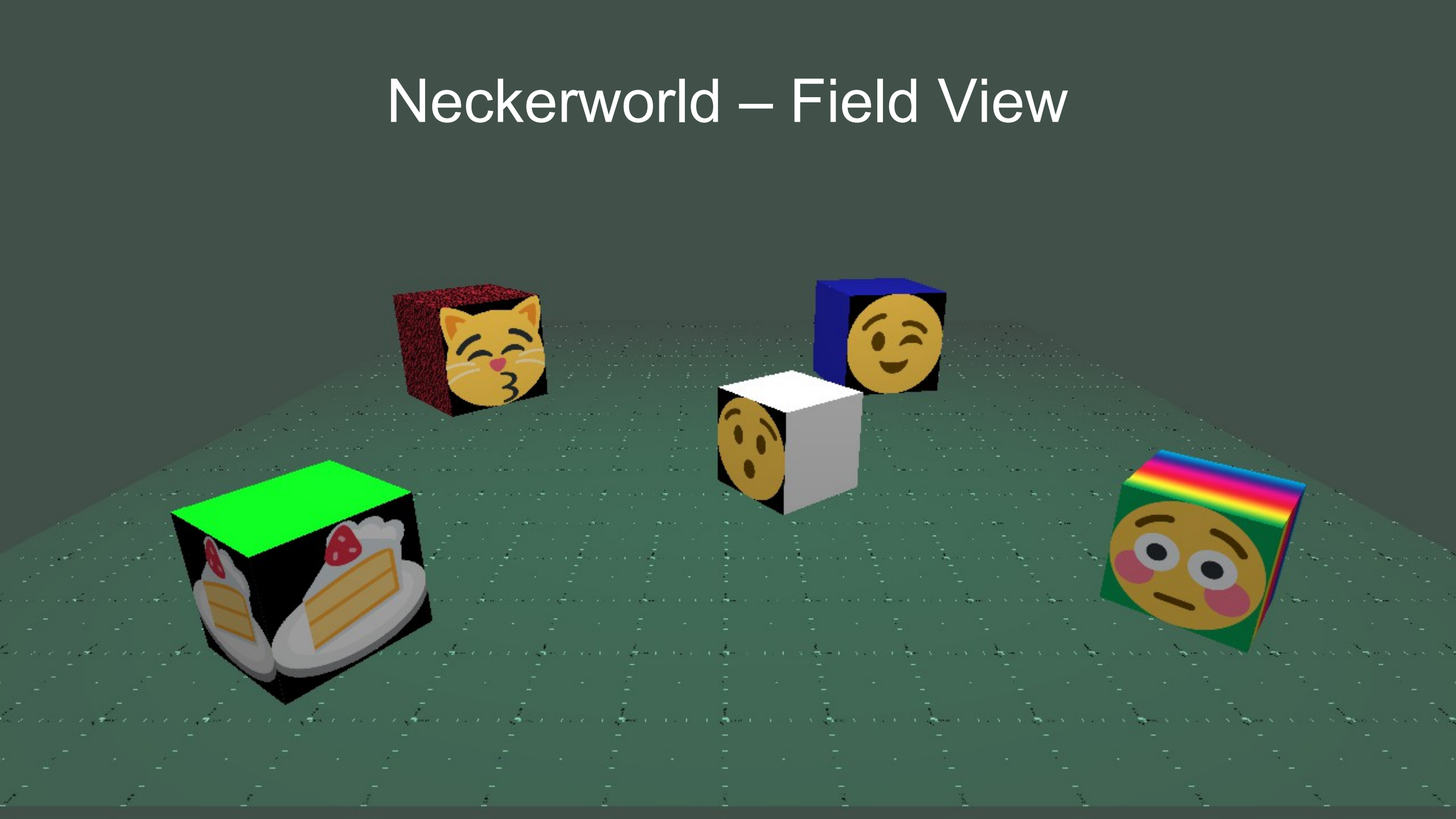


Females

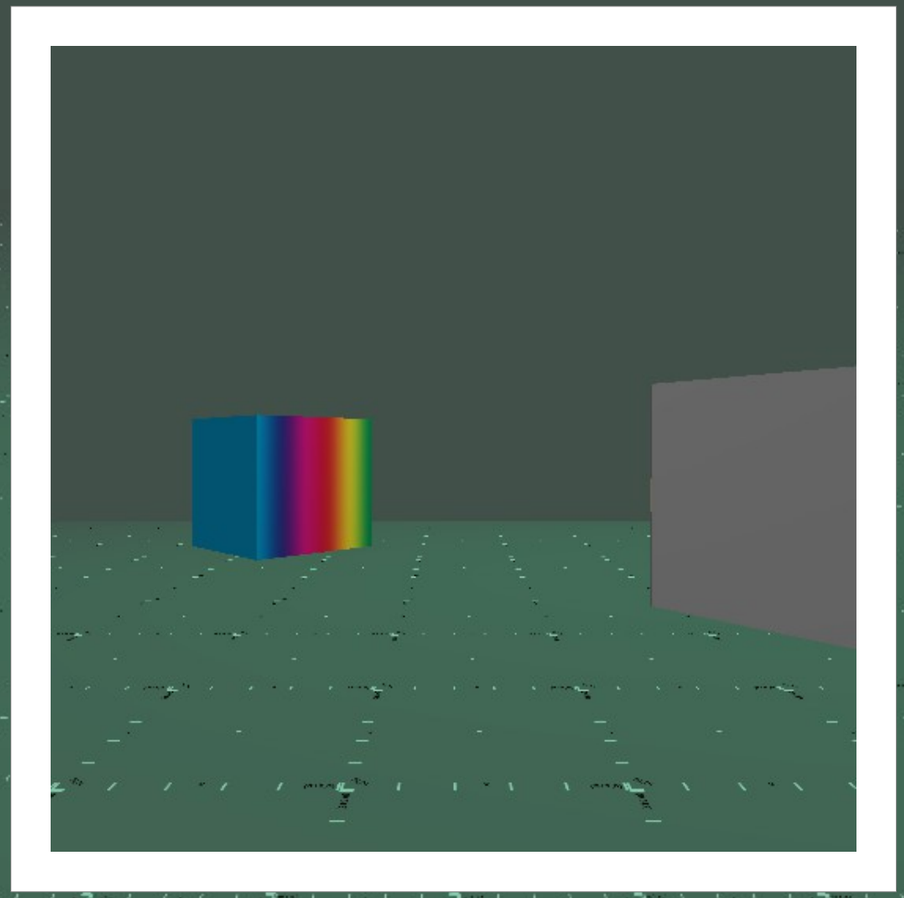
Resources

Enbys

Neckerworld – Field View



Neckerworld – Cube's Eye View



Neckerworld – Fundamental Questions

Given only the cube view, why do we perceive a larger 3D space?

Given constant motion of the view, why does the world appear stable?

How do we internally represent the objects around us?

What is the relationship between object detection and internal representations?

And many more ...

Neckerworld – AI and ML

Object detection – identifying an object in an image, placing a bounding box around the object and assigning a probability of a class to it.

Object classification – assigning a class to an image.

Image segmentation – identifying all pixels associated with a particular subset of an image.

Neckerworld – Object Detection Goals

Determine if there is one or more objects in the image.

Identify the type of object.

Provide a probability for the type.

Draw a bounding box around the object.

Determine its spatial position relative to the camera.

Neckerworld – Object Detection Outcomes

There is an object and you nailed it.

There were no objects and you agreed.

There was an object but you didn't see it.

There were no objects but you said you found one.

Neckerworld – Object Detection Score

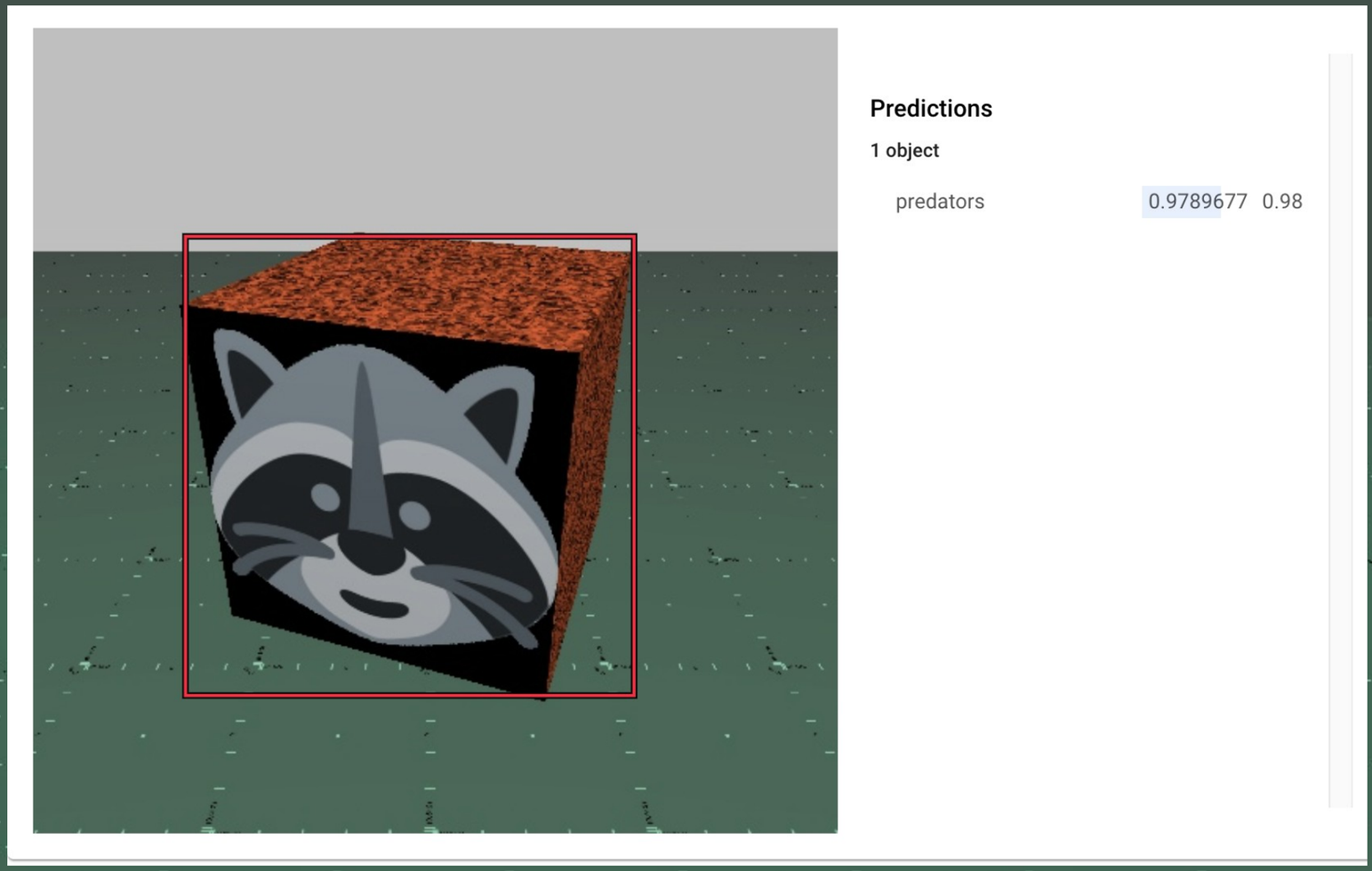
95% sure it's a Female

50% sure it's a Male

10% chance that it's a Predator

1% chance it's a Resource.

Neckerworld – Object Bounding Box



Neckerworld – Object Detection

Create a visual neural net model.

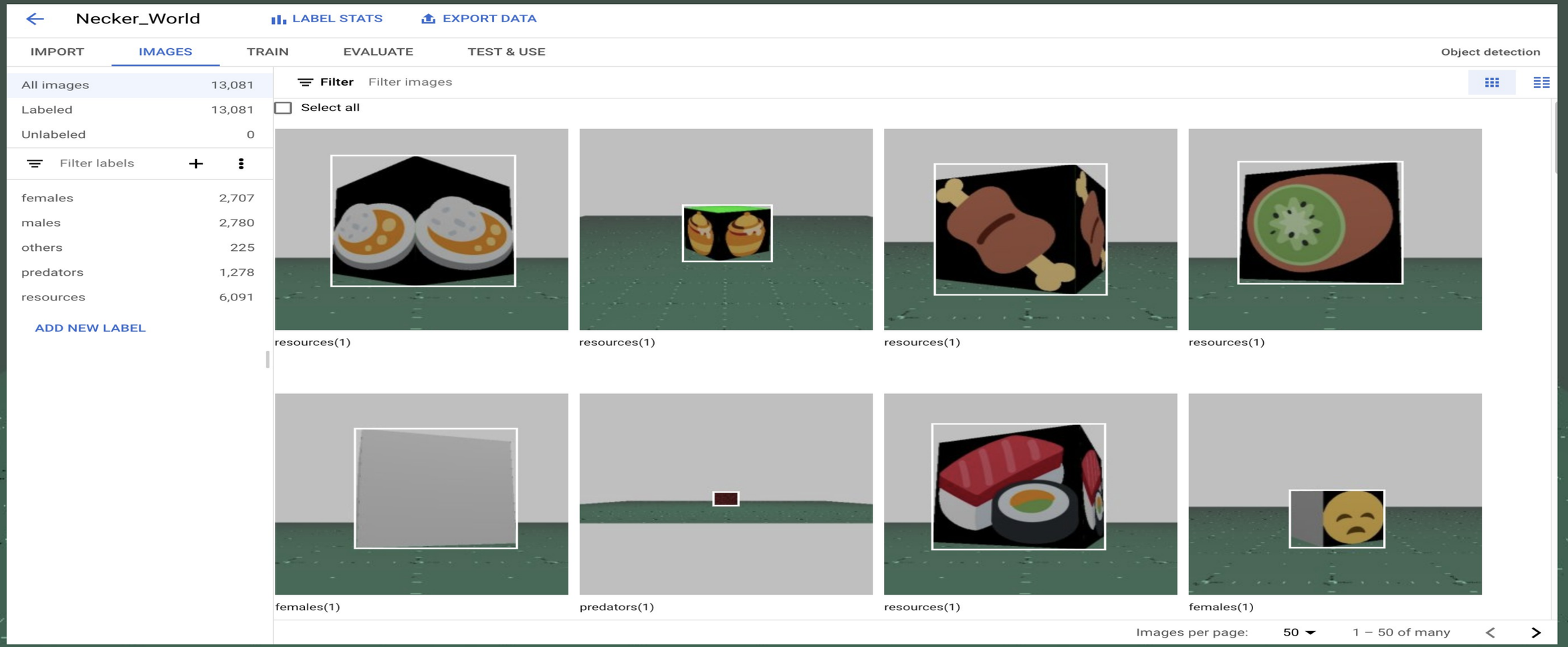
Train the neural net to identify the object.

Validate the model/training with validation images.

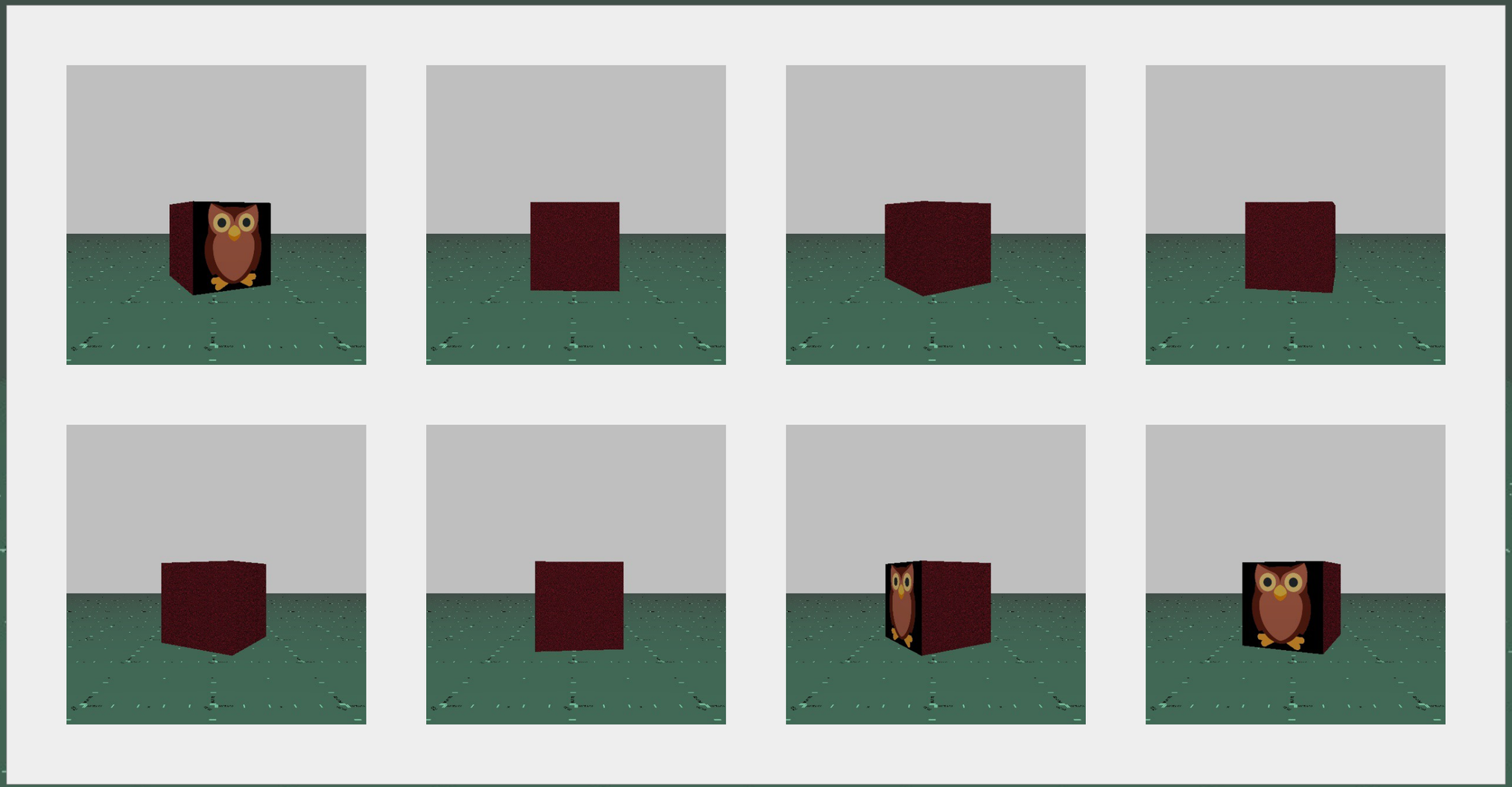
Test the model with final test images.

Deploy the model into production.

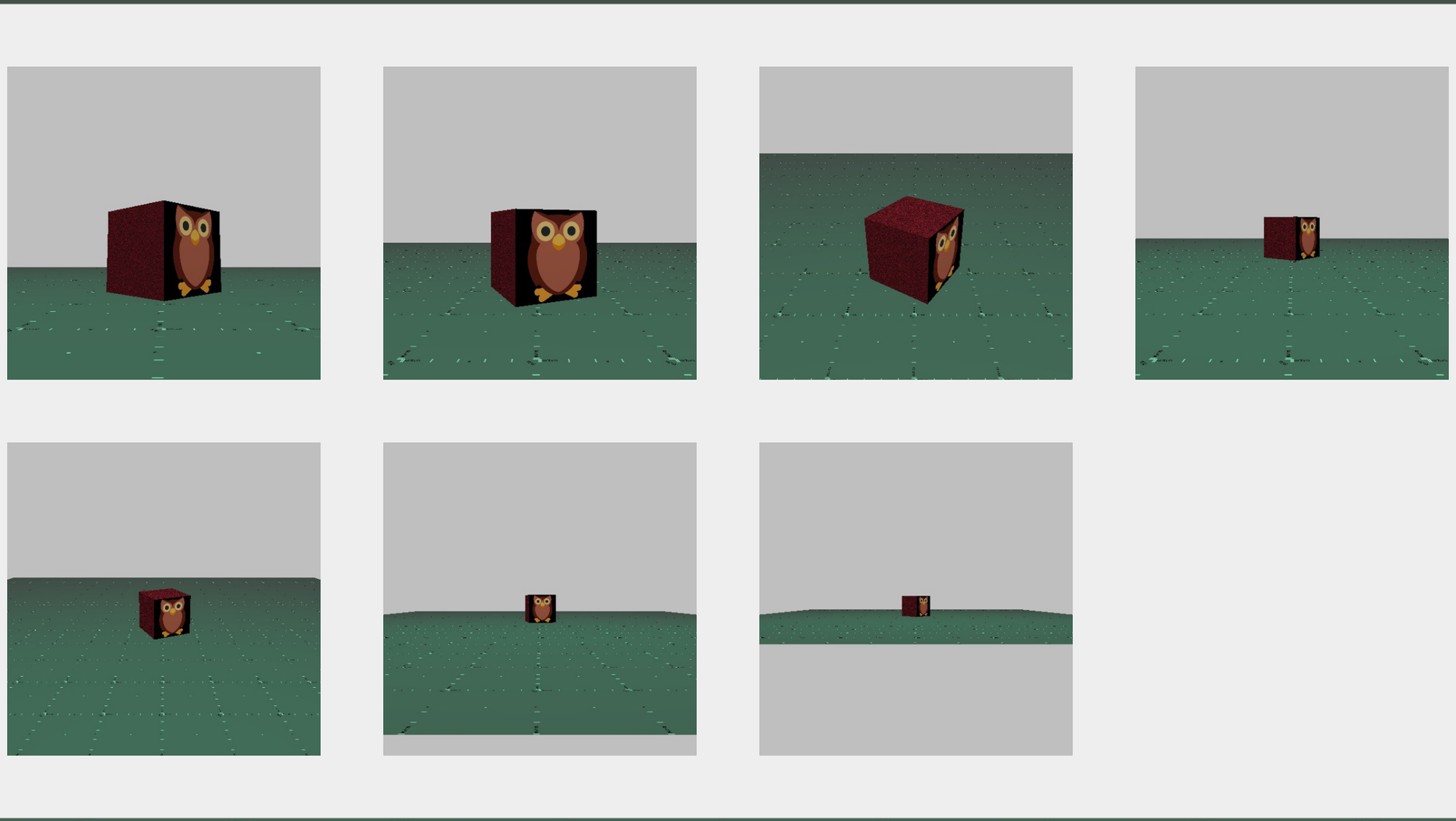
Neckerworld – Object Detection



Neckerworld – Generate 8 Random Rotations



Neckerworld – Create 7 Different Views



Neckerworld – Training Images

37	Male Players
+ 36	Female Players
+ 3	Enby Players
+ 17	Predators
+ 81	Resources
x 7	Unique Views
x 8	Random Rotations
= 9744	Training Images

Neckerworld – Training Results

Necker_World LABEL STATS EXPORT DATA

IMPORT IMAGES TRAIN EVALUATE TEST & USE Object detection

Model: Necker_World_20210310063927 Confidence threshold: 0.5 IoU threshold: 0.5

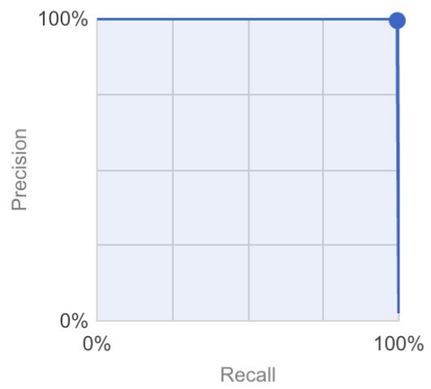
Filter labels

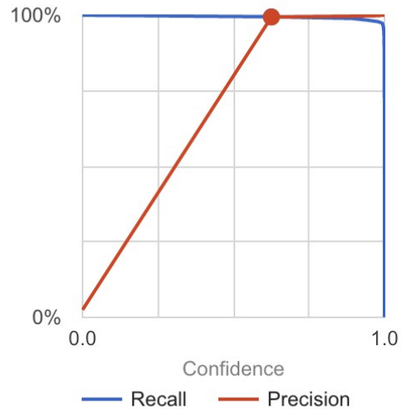
All labels	0.99426
females	0.98513
males	0.98747
others	0.97674
predators	0.99607
resources	0.99670

All labels

Total images	11,773
Test items	1,308
Total objects	1,308
Object to image avg	1
Precision	99.39%
Recall	99.46%

Use the slider to see which confidence threshold works best for your model on the precision-recall tradeoff curve.
Learn more about these metrics and graphs.





Neckerworld – Precision, Recall and IoU

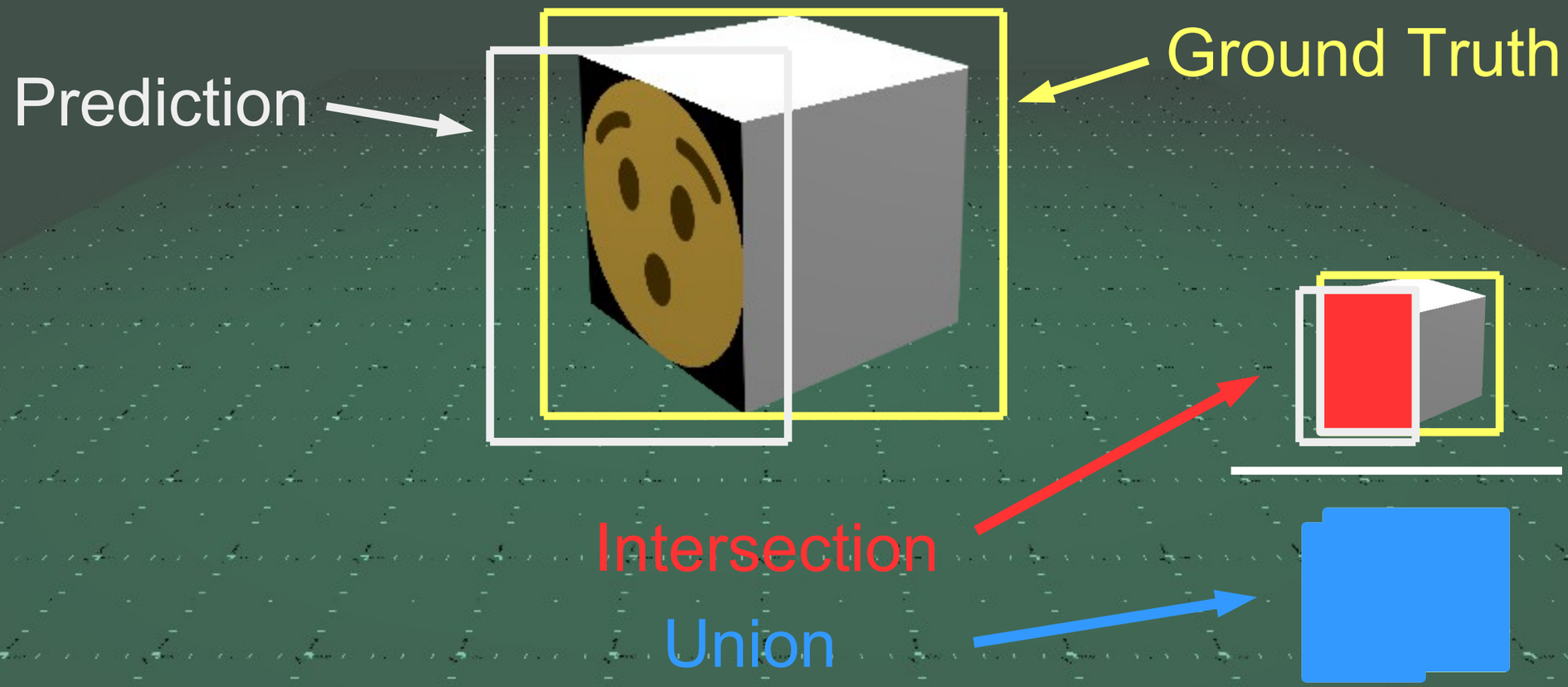
Precision - is the ability of a classifier to identify relevant objects only. It is the proportion of true positive detections.

Recall - measures the ability of the model to find all relevant cases (that is, all ground-truths) - the proportion of true positives detected among all ground-truths.

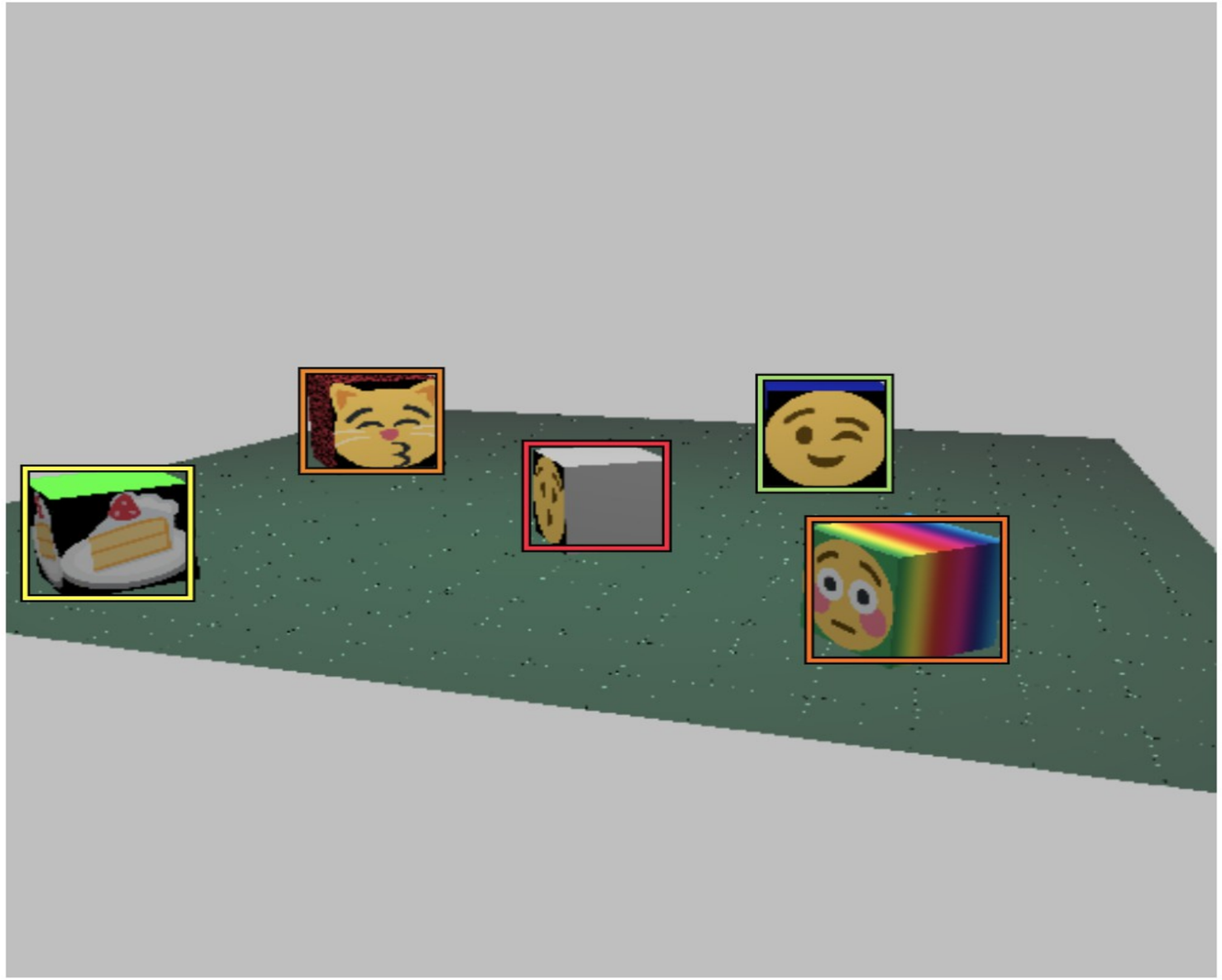
Intersection over Union - evaluates the overlap between the ground-truth mask and the predicted mask.

From: Kiprono Elijah Koech - Object Detection Metrics With Worked Example

Neckerworld – Intersection over Union (IoU)



Neckerworld – Predictions

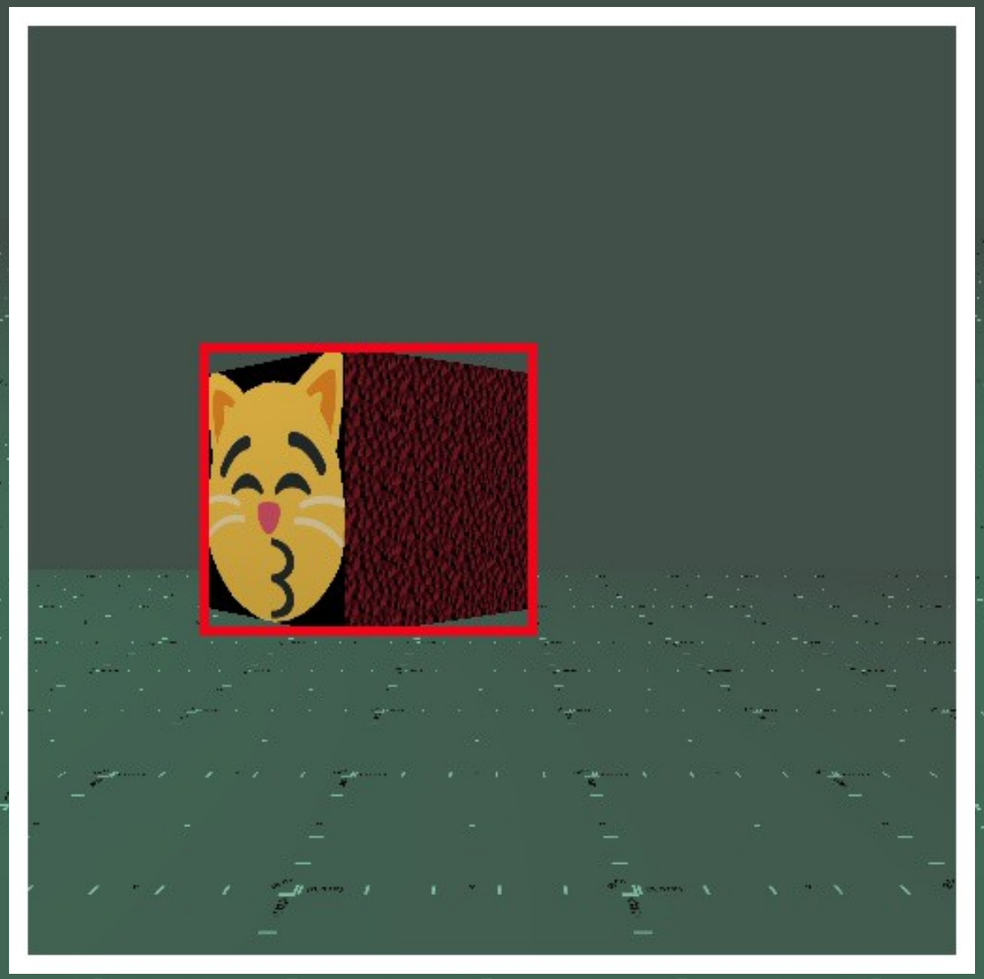


Predictions

5 objects

males	0.9998056	1.00
others	0.9986324	1.00
resources	0.9980274	1.00
females	0.9933228	0.99
predators	0.9867263	0.99

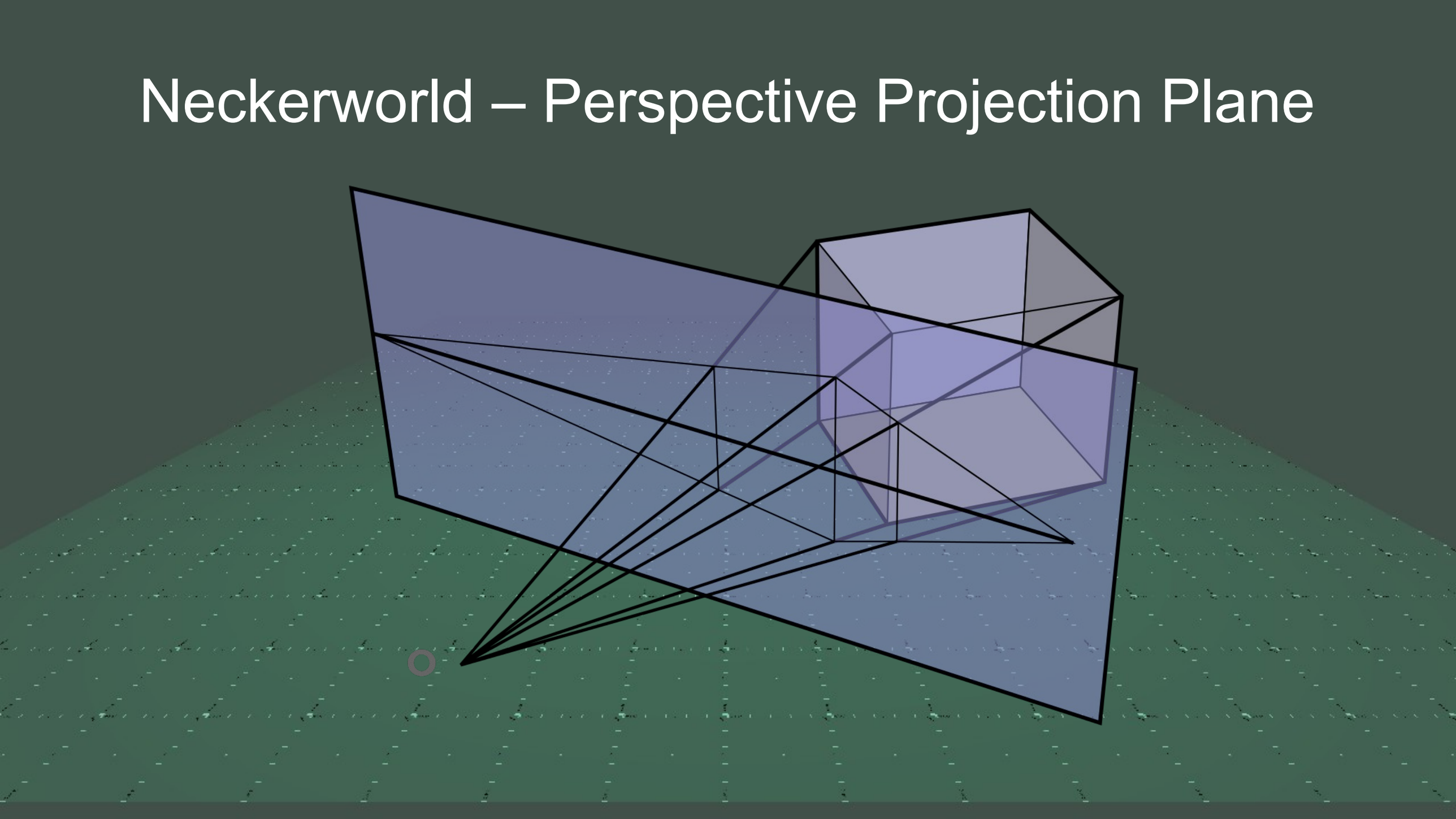
Neckerworld – Inverse Perspective Projection



Neckerworld – Perspective Projection in Art

Masolino da Panicale's St. Peter Healing a Cripple and the Raising of Tabitha (c. 1423), the earliest extant artwork known to use a consistent vanishing point.

Neckerworld – Perspective Projection Plane

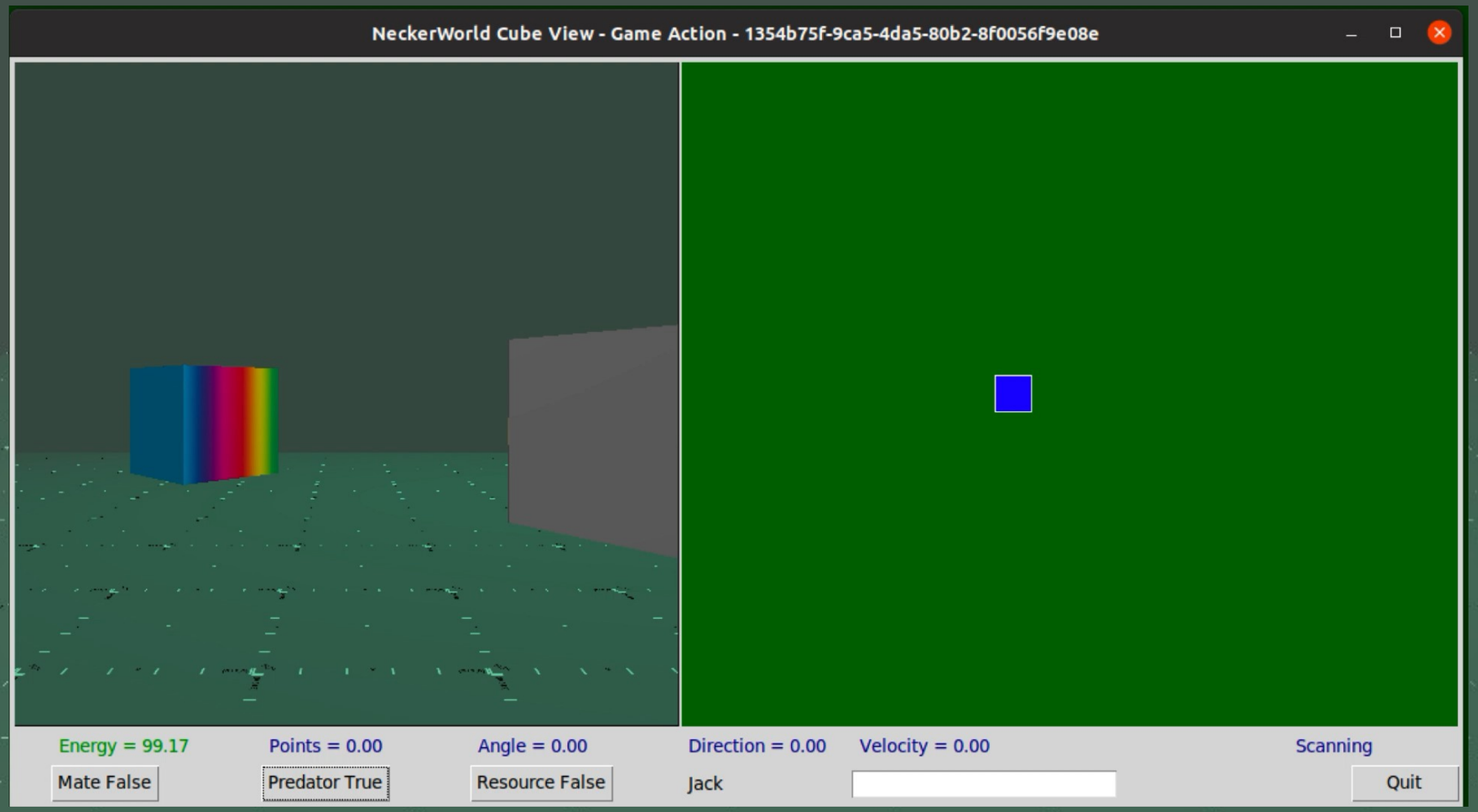


Neckerworld – Coordinate Systems

Object Coordinates
World Coordinates
Camera or View Coordinates
Normalized Display Coordinates
Viewport Coordinates
Window Coordinates
Screen Coordinates

Neckerworld – Cube Control Panel

Neckerworld – Game On



Neckerworld – A Computer Vision Game

Questions?

Contact

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