Computational Vision Models and Occupational Standards for Acuity and Contrast Sensitivity

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http://vision.arc.nasa.gov/personnel/al/ahumada.html

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Willa Hisle-Ahumada, O.D.,
San Jose State University Foundation

Outline

- Vision requirements problem
- Image discrimination model
- Model calibration
- Prediction of crack visibility as a function of crack size, acuity, and contrast sensitivity
- Psychophysical validation of model

Maintenance Inspection is Highly Visual

There are no vision standards for aviation maintenance inspectors

Occupational Visual Acuity Standards

Non-empirical

Aircraft Mechanics & Inspectors

Air Force Personnel

Air Traffic Controllers

Bridge Inspectors

Coast Guard Personnel

Commercial Motor Vehicle Drivers

Correctional Officers

Locomotive Engineers

Nuclear Power Plant Inspectors

Pilots - all classes

Welding Inspectors…

Empirical

Firefighters

Uncorrected Distance Visual Acuity
National Fire Protection Association

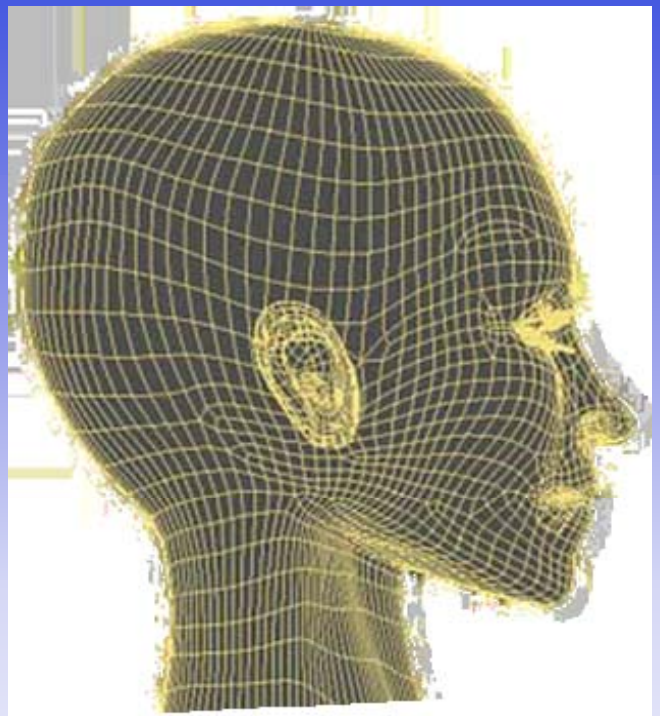
Police Officers

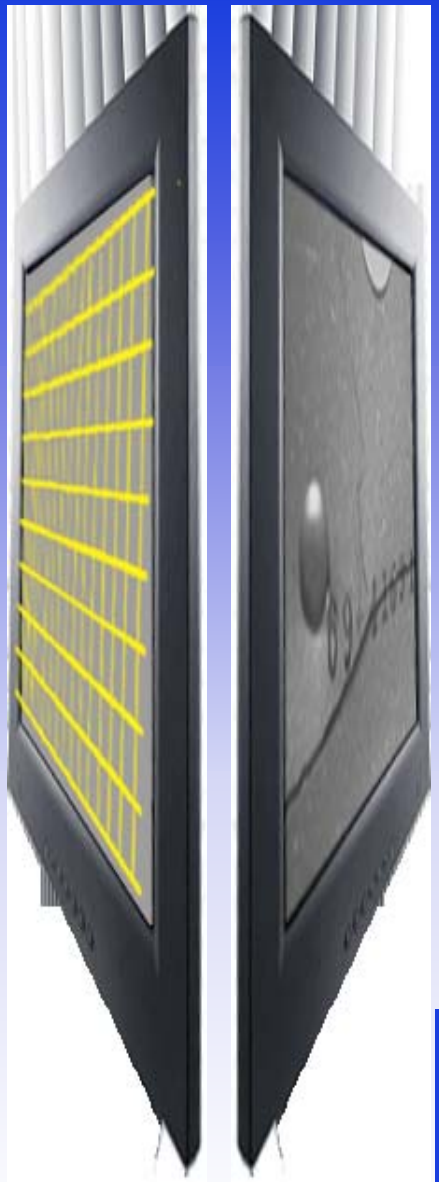
Uncorrected Distance Visual Acuity
Columbus (Ohio) Police Department

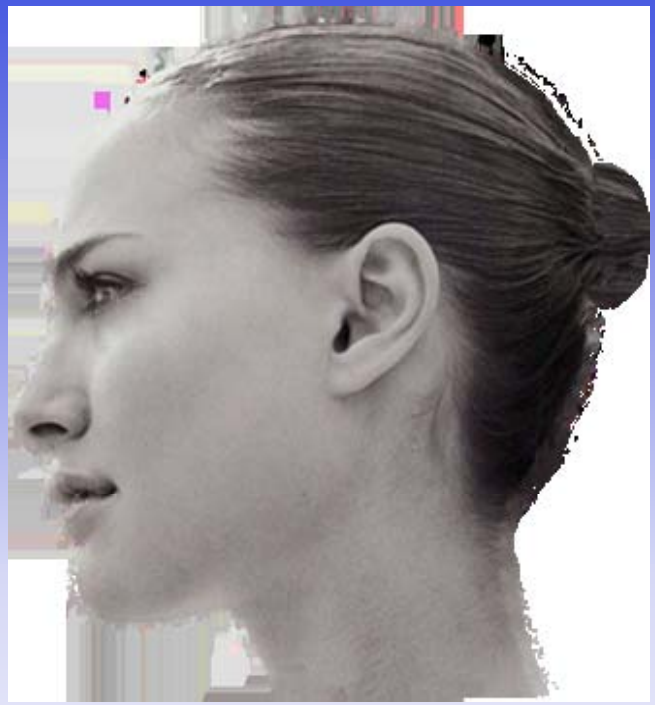
Basket Making Workers

Best Distance & Near Visual Acuity
Longaberger Company of Dresden, Ohio

Proposed Standard-Setting Method







COMPUTATIONAL MODELING

PSYCHOPHYSICAL DATA COLLECTION

Psychophysical Modeling Assumptions

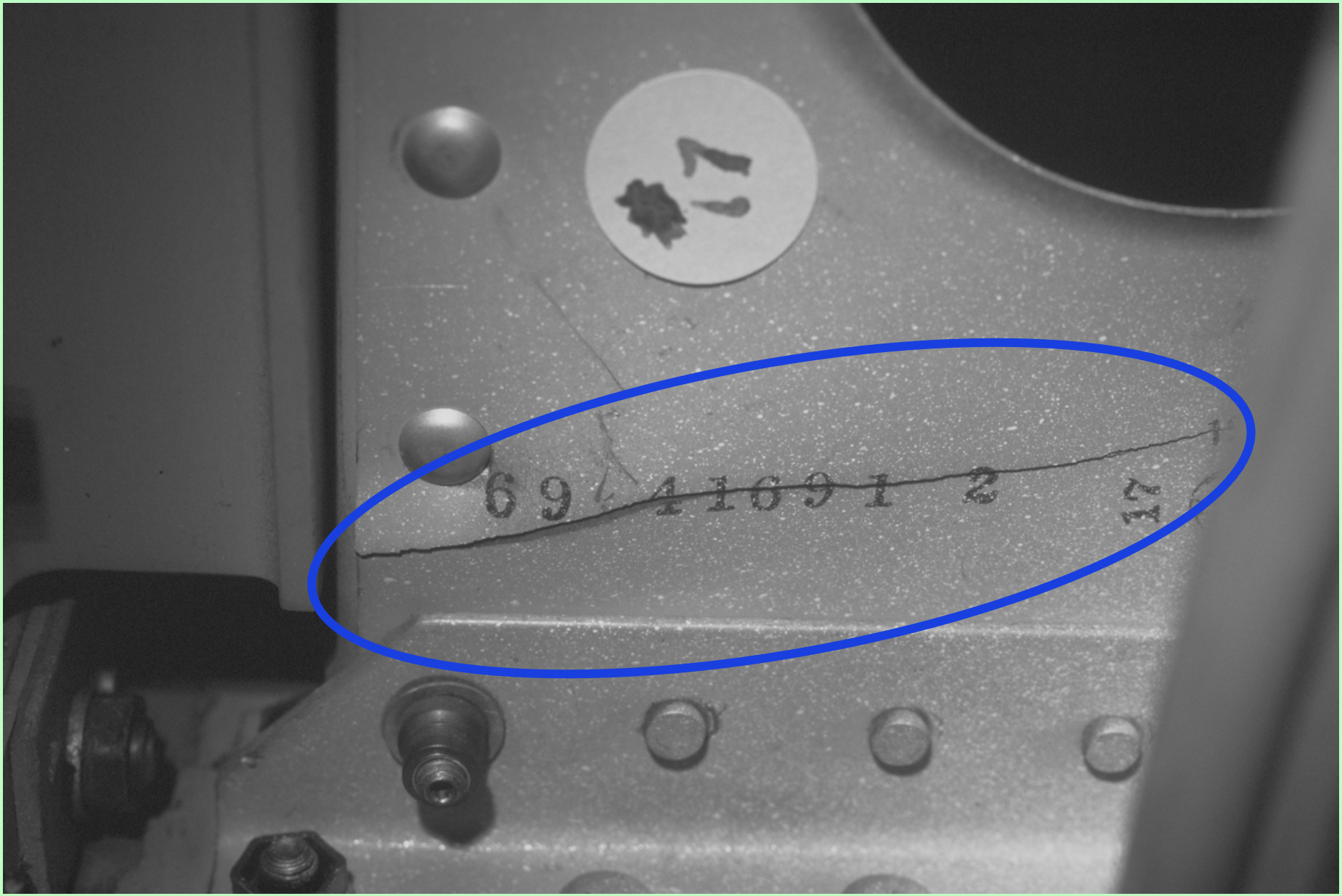
Physical model of crack:

- Dark line segment
- Possible alternative:
  - Light and dark line
    (negligible average luminance)

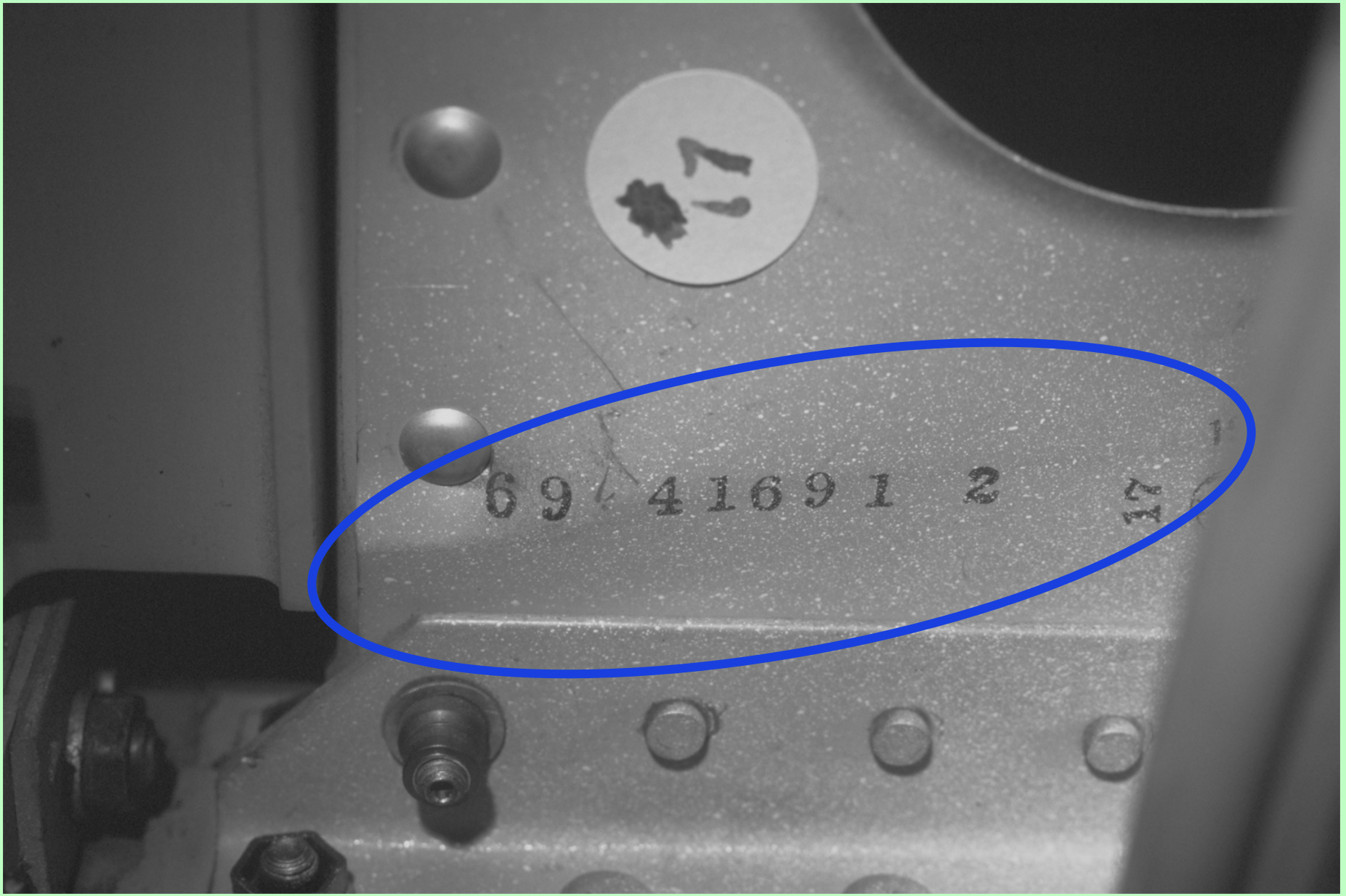
Model of vision loss:

- Image blur
- Possible alternative:
  - Scotoma (blind spot)

Original Crack Image

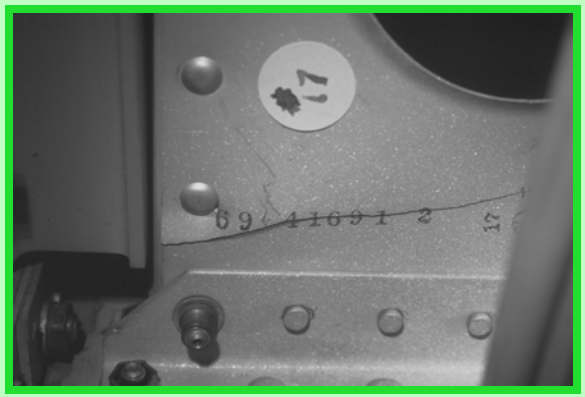


Crack Removed From Image

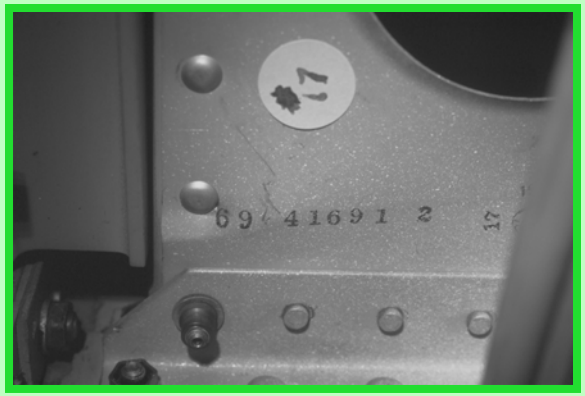


Masked Visible Contrast Energy Model

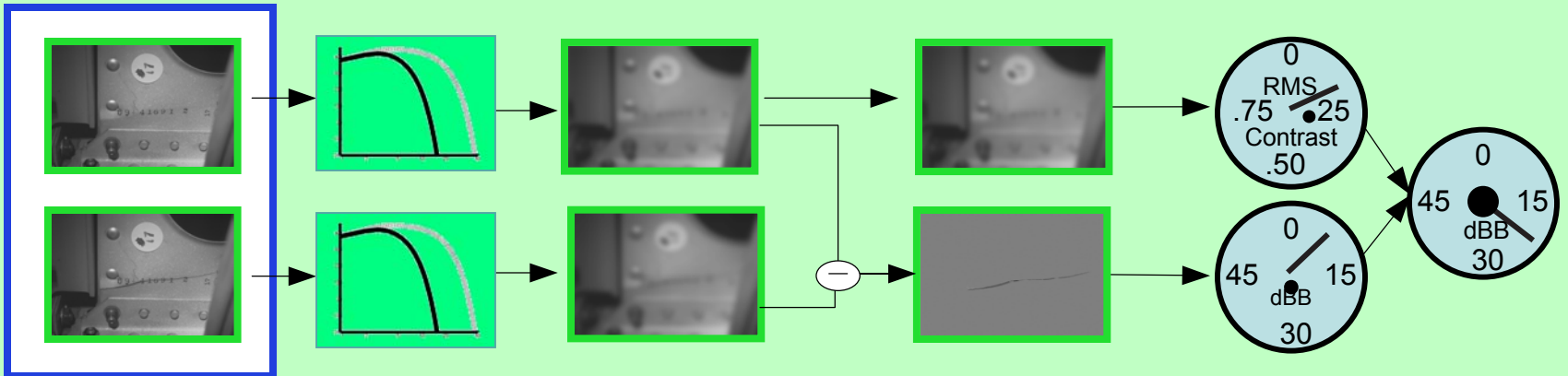
Crack Image



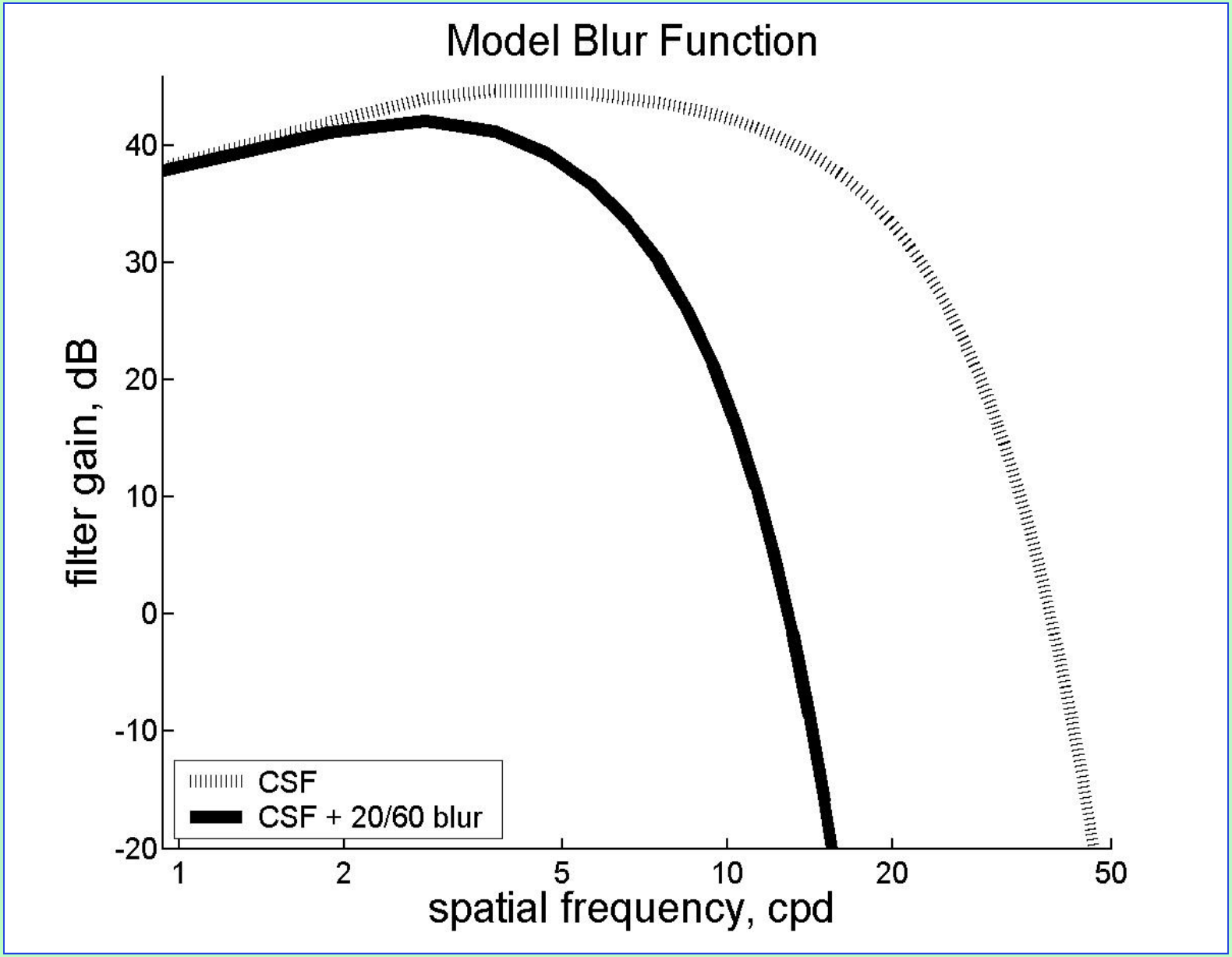
Crack-Removed Image



Full Model

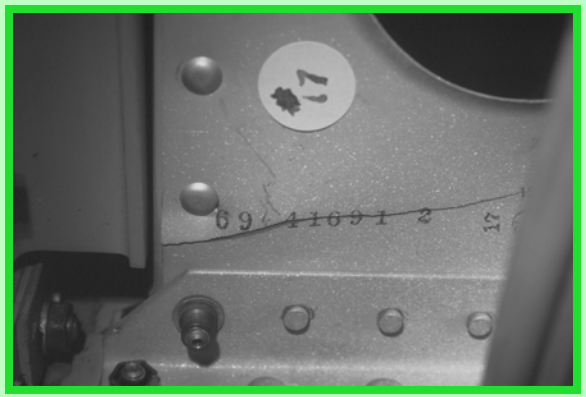


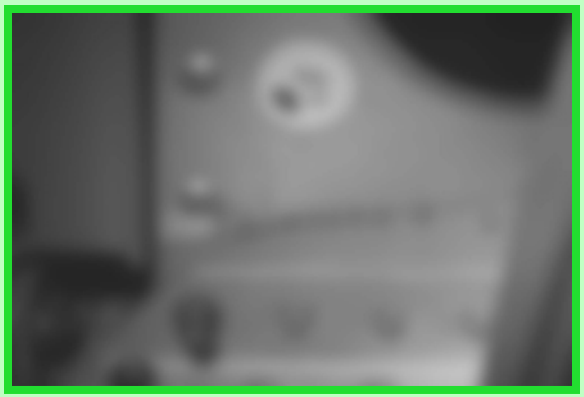
Contrast Sensitivity Function



Masked Visible Contrast Energy Model

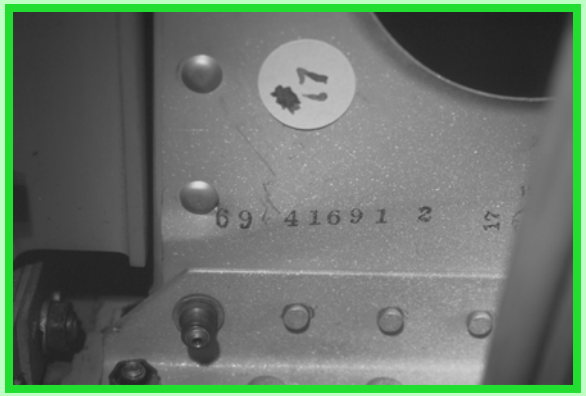
Original Image





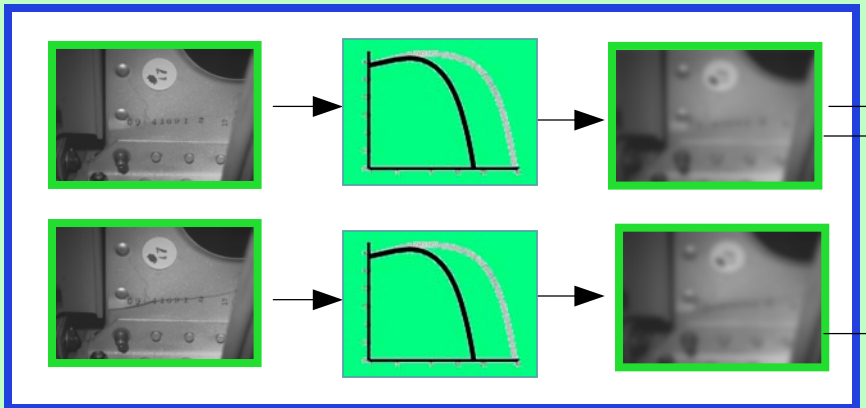
Blurred Crack Image

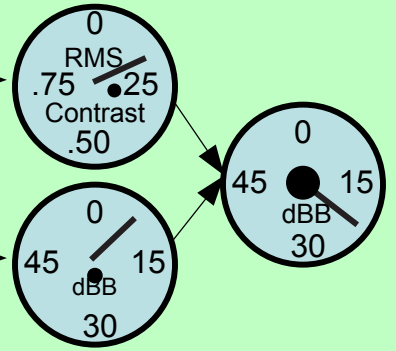
Crack Removed Image



Blurred Crack-Removed Image

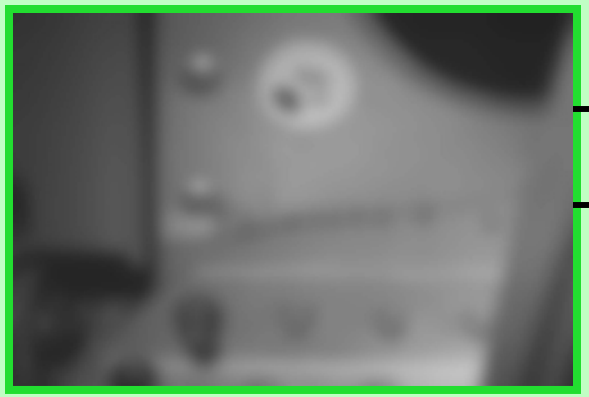
Full Model

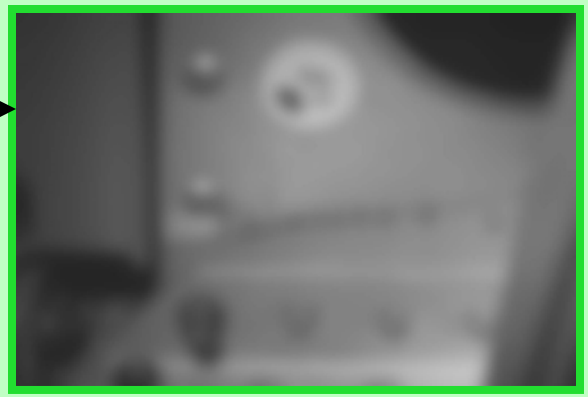




Masked Visible Contrast Energy Model

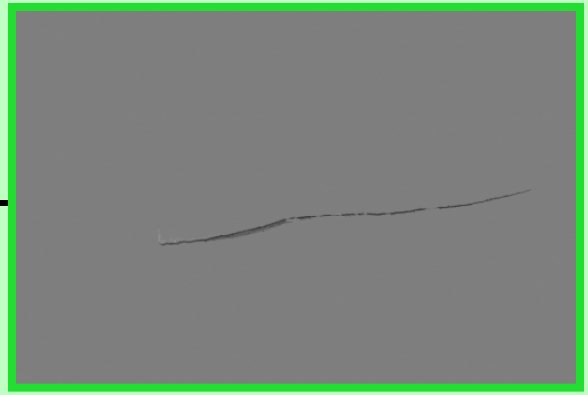
Blurred Original Image





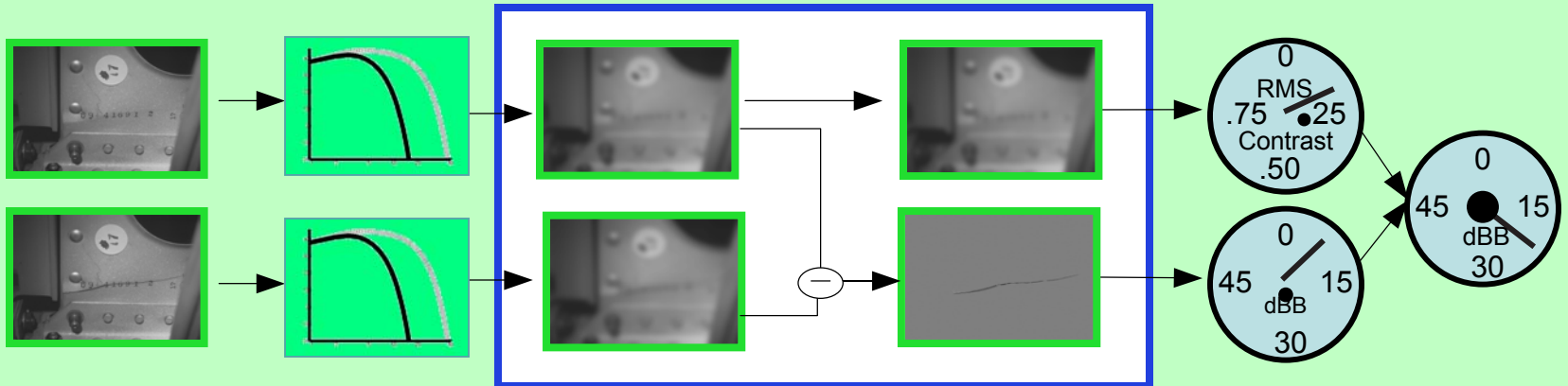
Masking Image (Blurred Original Image)

Blurred Crack Removed Image



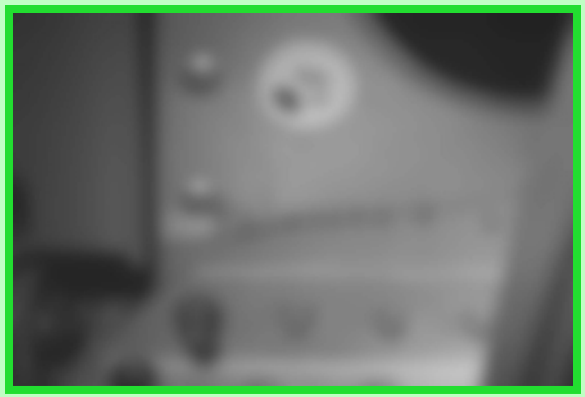
Signal Image (Difference Image)

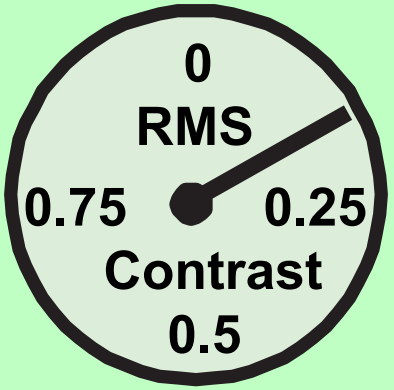
Full Model



Masked Visible Contrast Energy Model

Blurred Crack Image

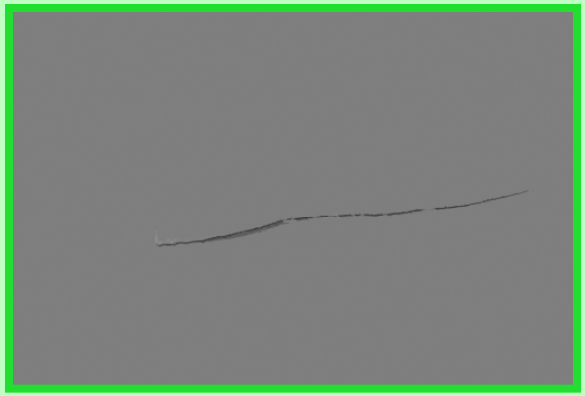


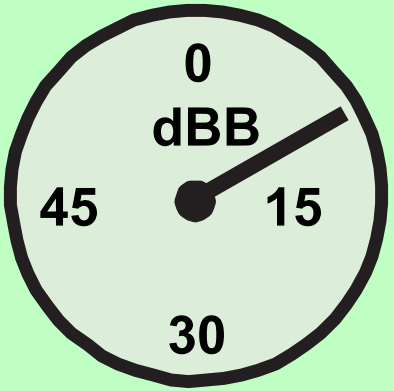


Masking Meter:

RMS Contrast

Difference Image

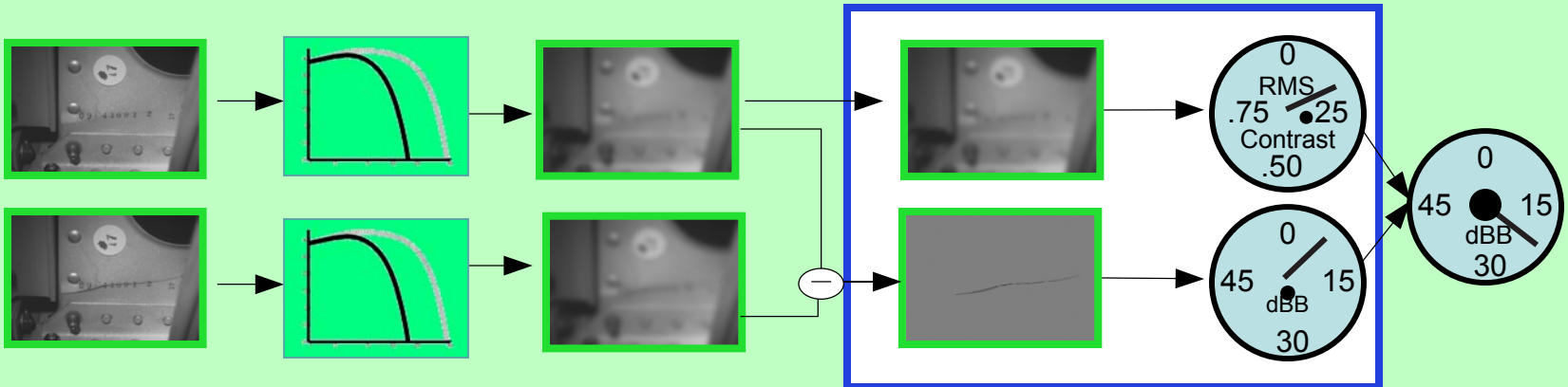




Signal Meter:

Threshold Contrast Energy

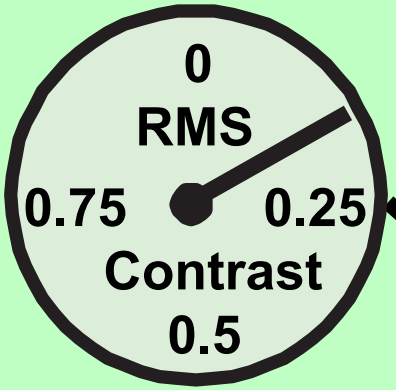
Full Model



Masked Visible Contrast Energy Model

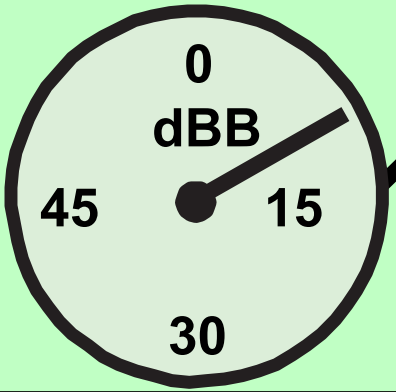
Masking Meter:

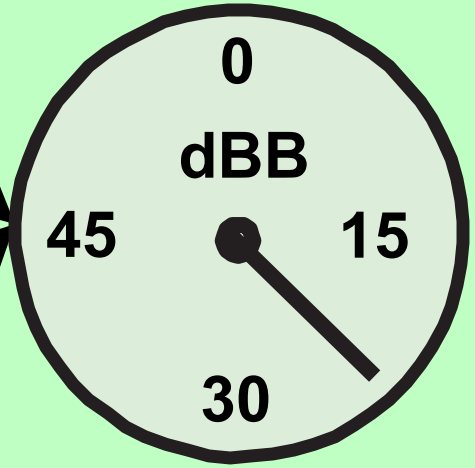
RMS Contrast



Signal Meter:

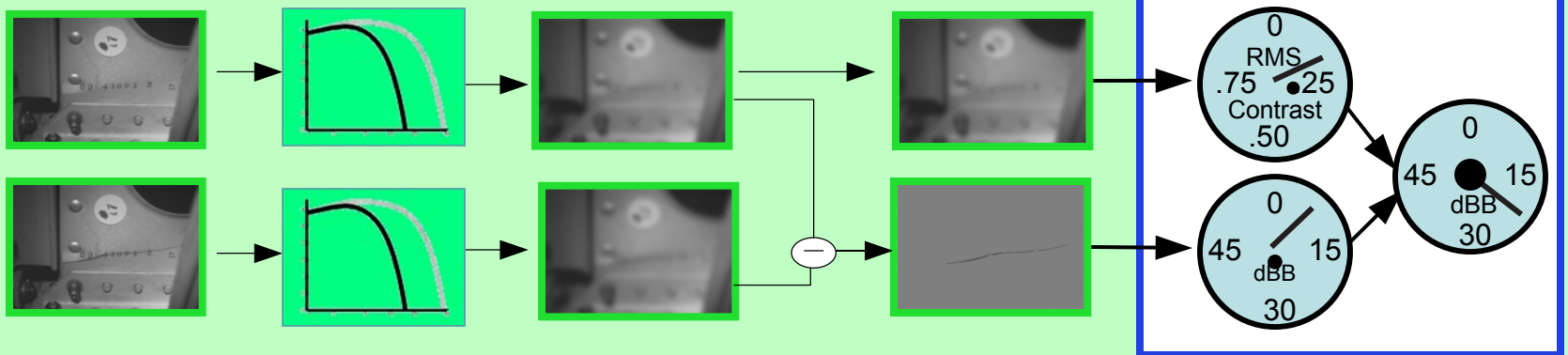
Threshold Contrast Energy





Masked Threshold

Full Model



Model Calibration

Subset of Modelfest stimuli

Model parameters:

DOG CSF:

central blur spread: 2 min

surround spread: 16 min

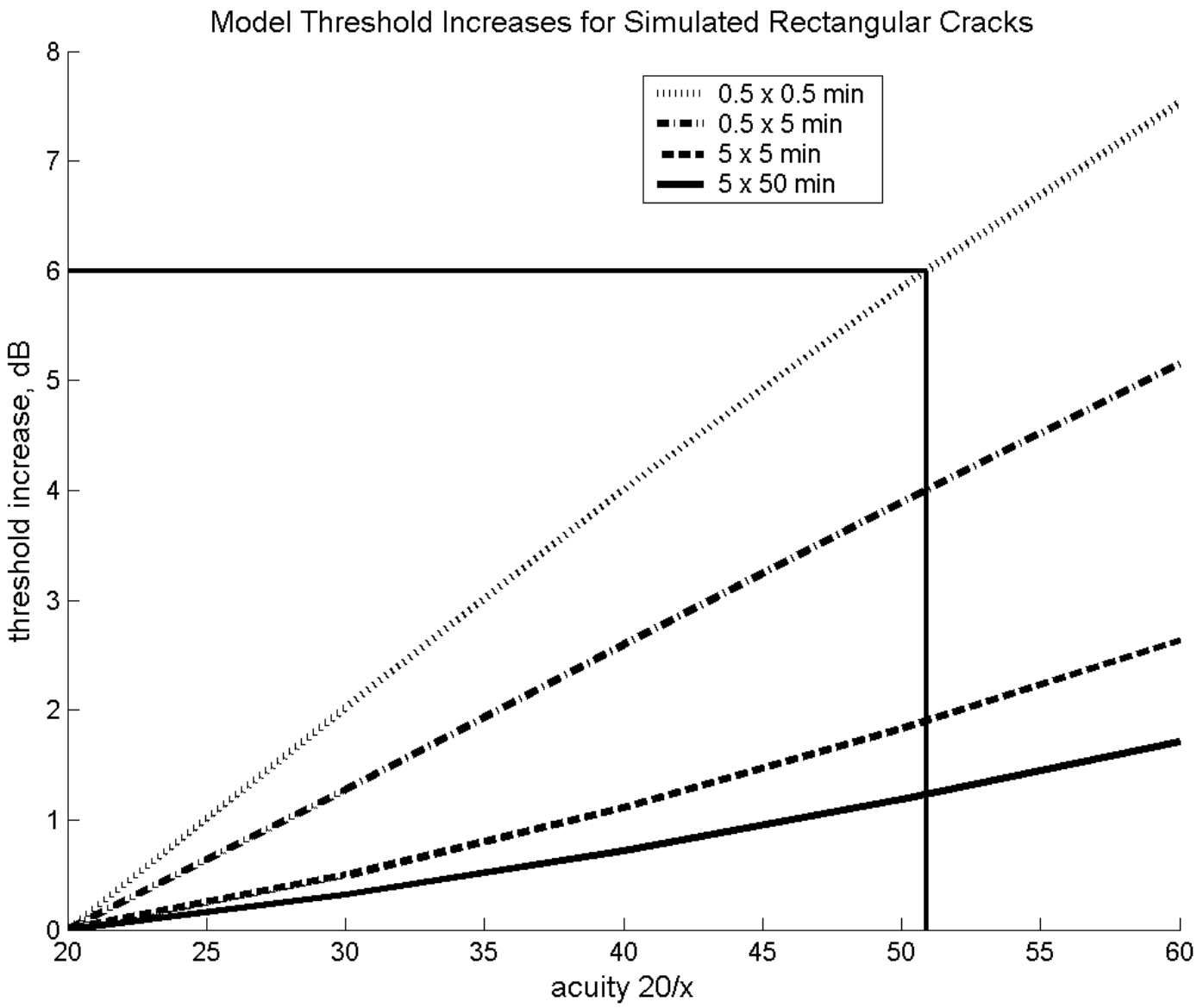
DC gain: 0.32

*Peak contrast sensitivity: 172

*Summation exponent: 2.5

*adjusted

Prediction of crack visibility



Next Steps

Does psychophysical testing with crack images validate the model?

Planned experiments with
34 images, 57 cracks

Do model improvements help?
Better contrast measure?
Better masking measure?
Multi-channel model?