Applying 3D sensing to novel problems

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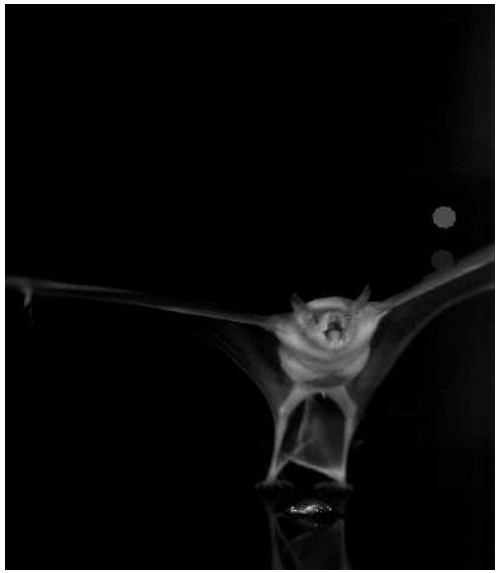
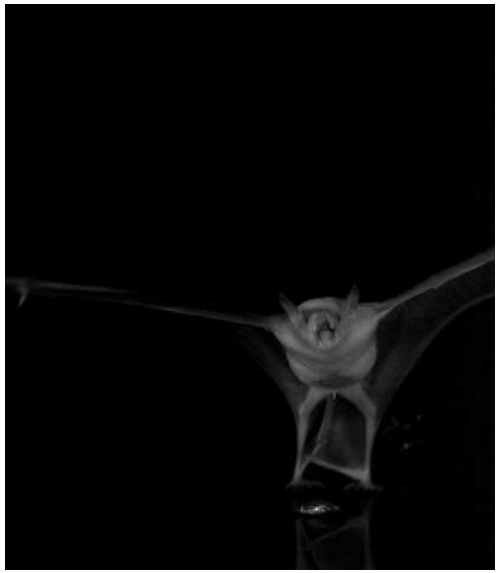
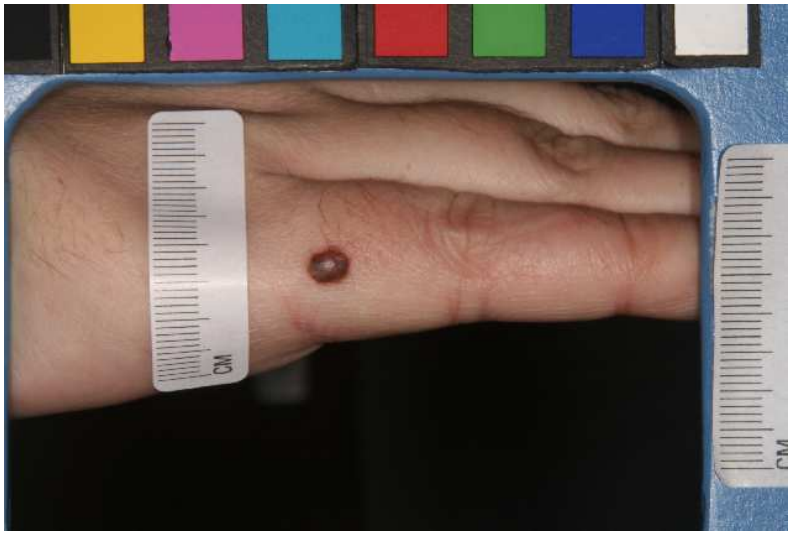


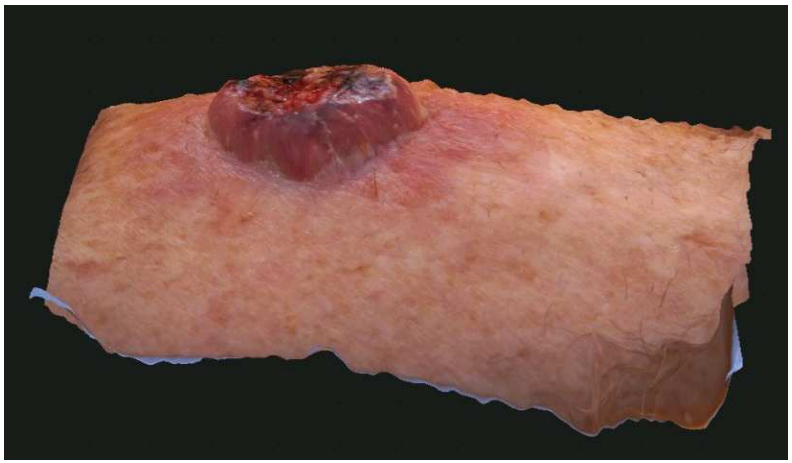


3D skin cancer analysis

Dynamic 3D shape analysis

Skin Cancer Analysis





Benefit of 3D data for segmentation and classification?

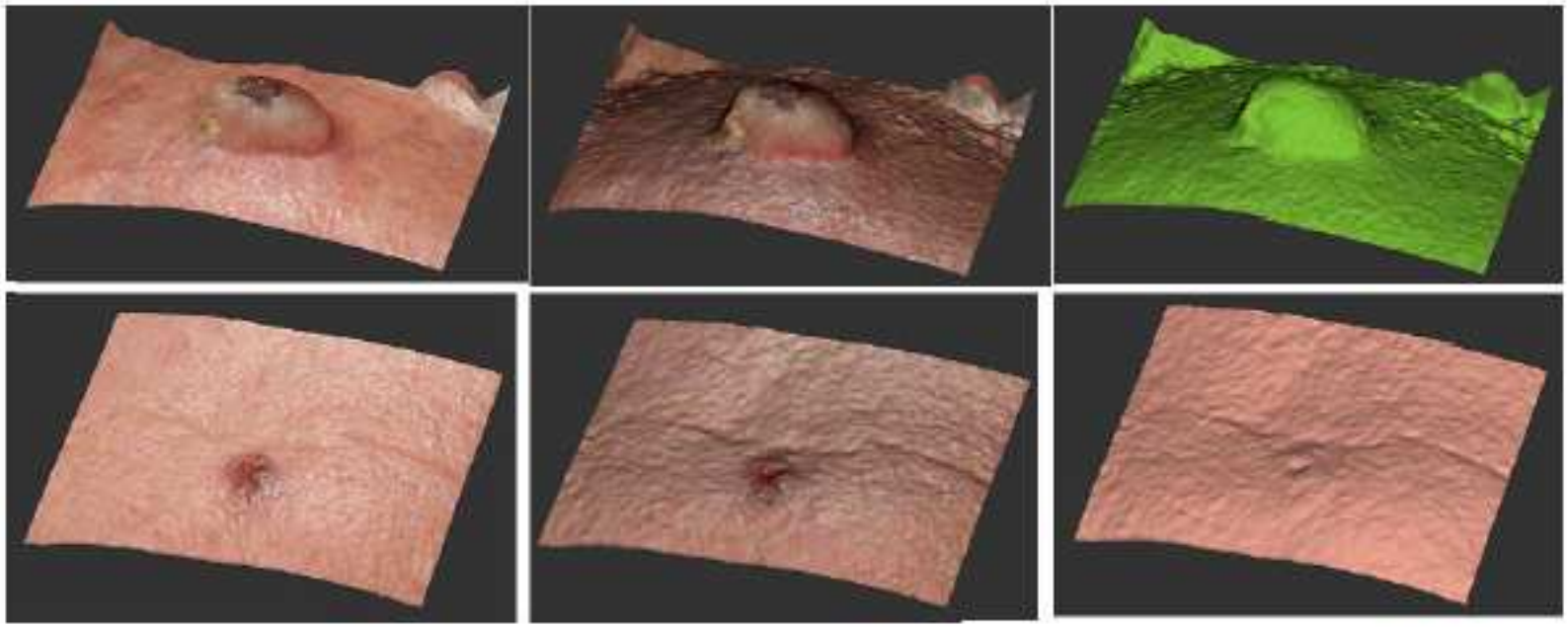
Xiang Li, Lucia Ballerini, Steven McDonagh

Stereo Camera System

7 megapixel RGB color digital SLR camera

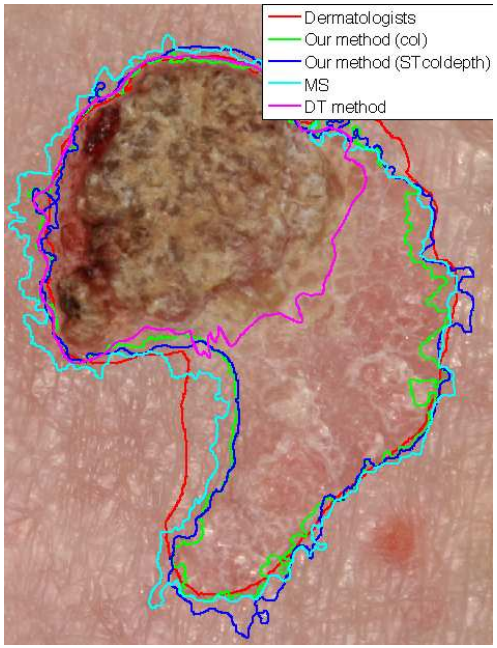
Typical 3D + Color Data

Registered XYZ data, RMS and sampling: 0.03 mm



Lesion Segmentation

Using a probabilisitic level-set framework



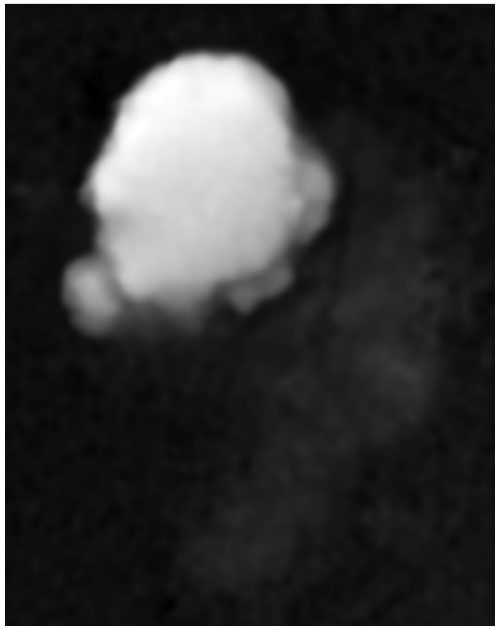
Needed for most diagnosis systems:

- compare properties inside vs outside
- shape of lesion, eg boundary irregularity

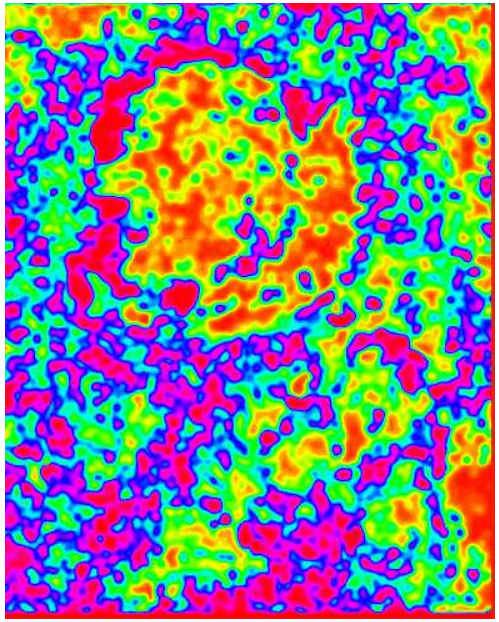
Lesion Segmentation

Using 3D and other properties

a* from La*b*



depth



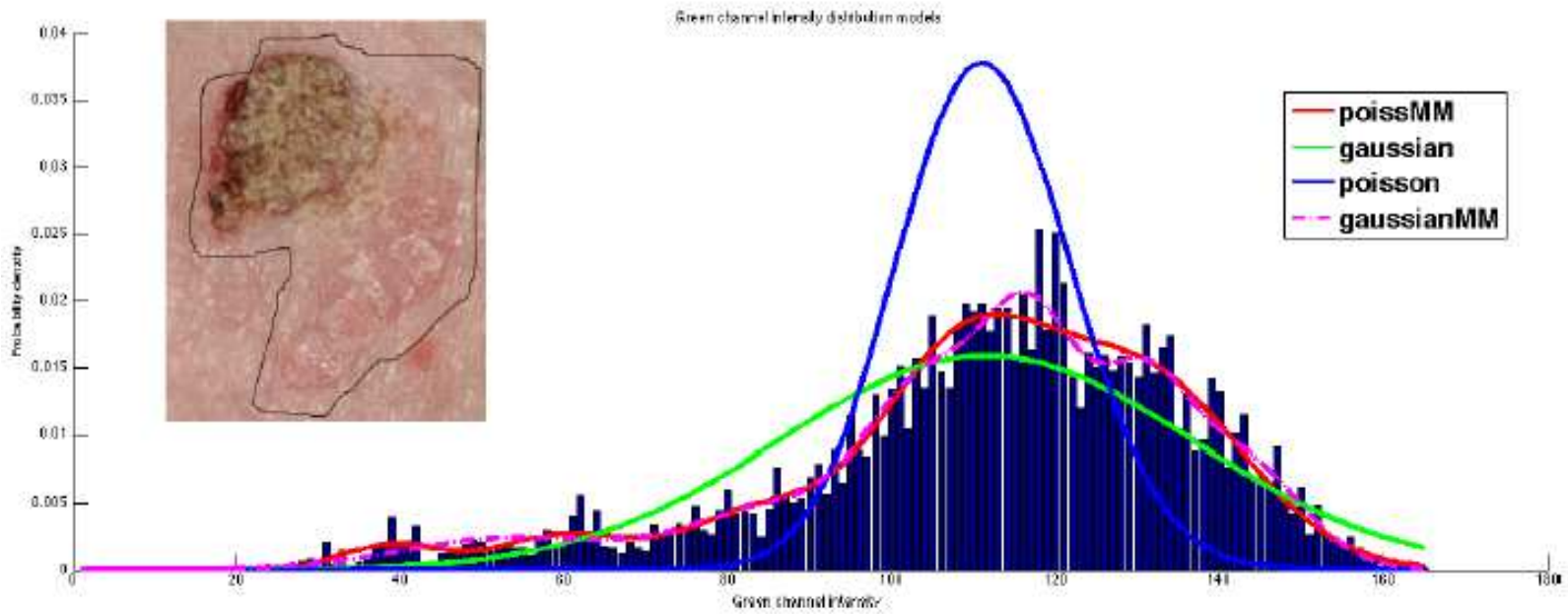
structure tensor

8 properties in total

Skin class models

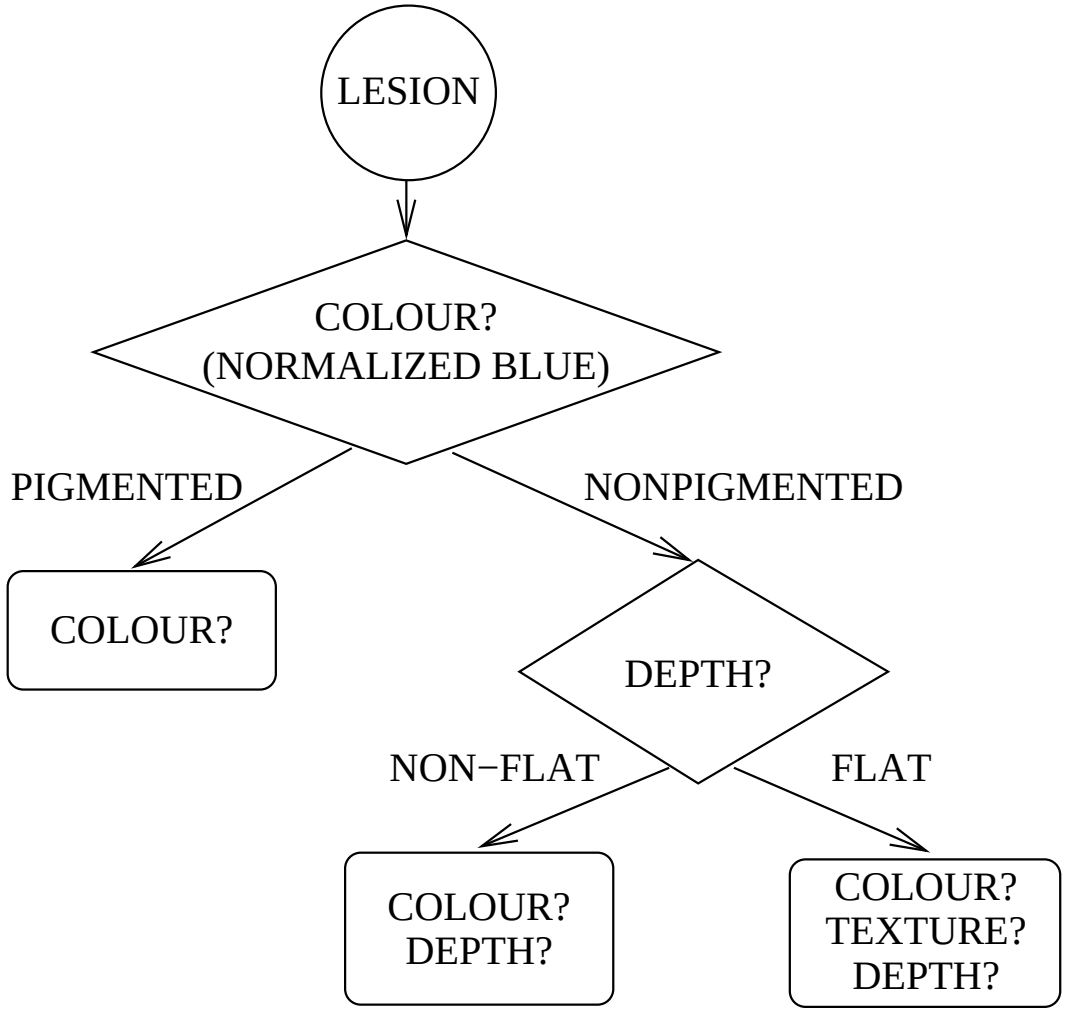
Used Gaussian Mixture Model to model interior/exterior

1D example:



GMM: pink, PMM: red, G: green, P: blue

Two Level Hierarchical Algorithm



Experiments

20 lesions, 5 classes

8 medics hand-segment

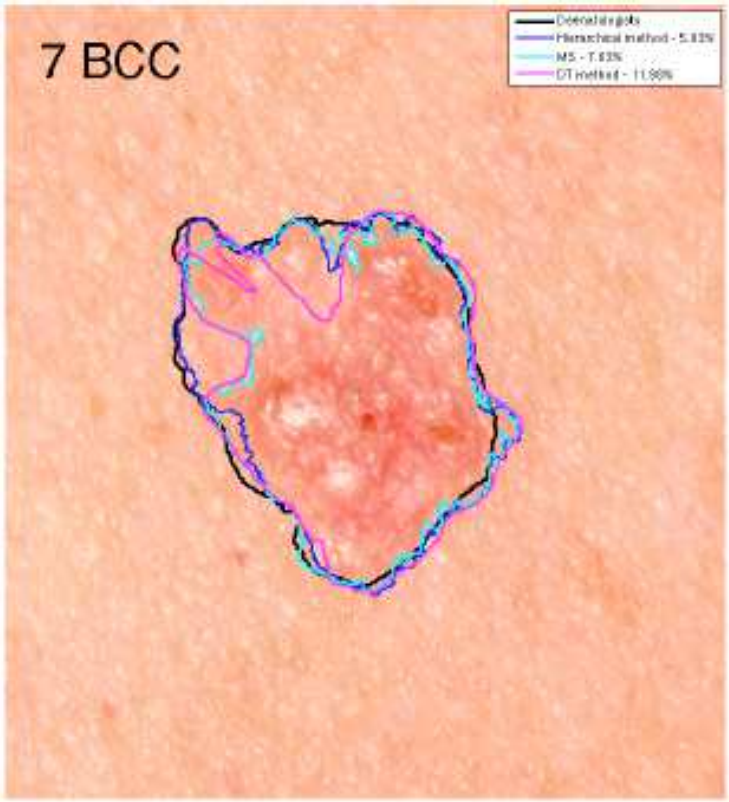
Ground truth: pixels selected by ≥ 4 medics

Compared to popular Mumford-Shah automatic region segmentation and Xu's algorithm

XOR evaluation:

$$\frac{\text{algorithm XOR manual}}{\text{algorithm UNION manual}} \times 100$$

Segmentation Example



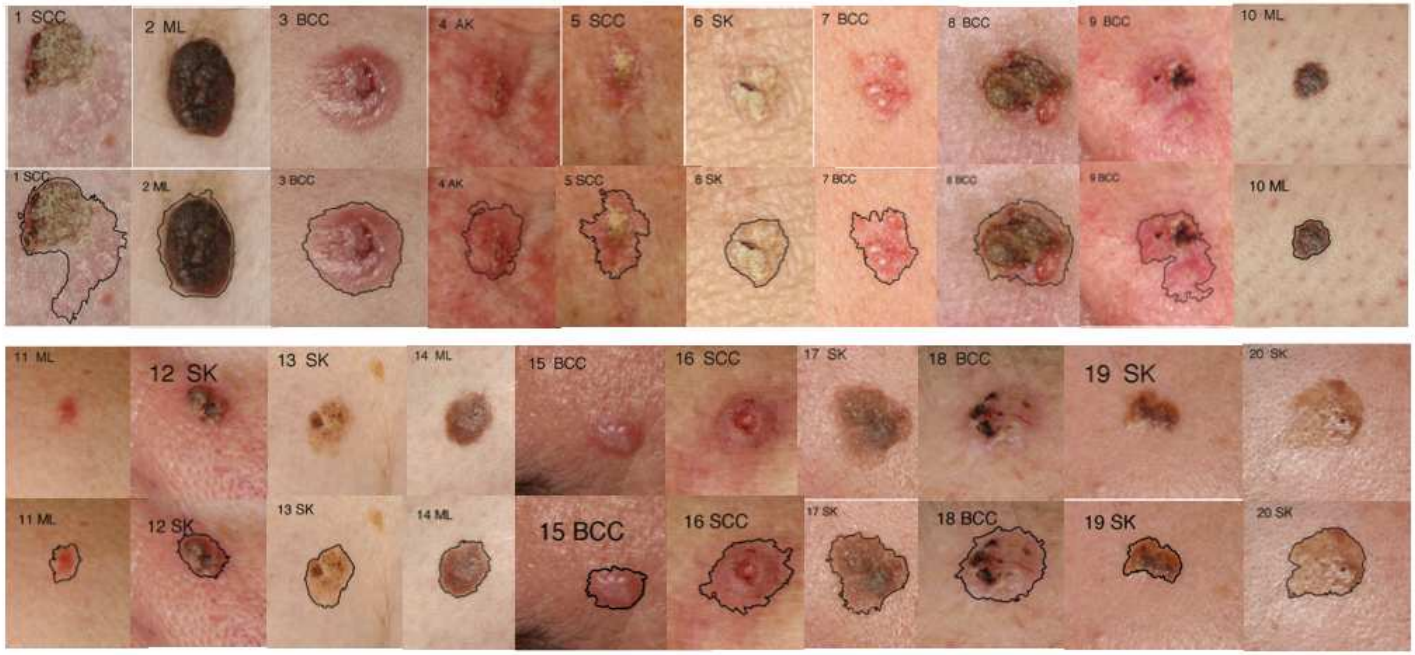
black: manual

blue: new hierarchical

cyan: Mumford-Shah

pink: other

Twenty Segmentations



Algorithm Comparison

XOR scores (small is better)

XOR rate	Medics	Flat	2-Hier	MS
All lesions	11.4	9.1	8.7	15.4
Pigmented	6.4	6.6	5.2	10.5
Non-pigmented	14.1	10.5	10.6	18.1

Skin Cancer Classification Using Depth

Five non-melanoma classes

AK - Actinic Keratosis

BCC - Basal Cell Carc.

ML - Mole

SCC - Squamous Cell Carc.

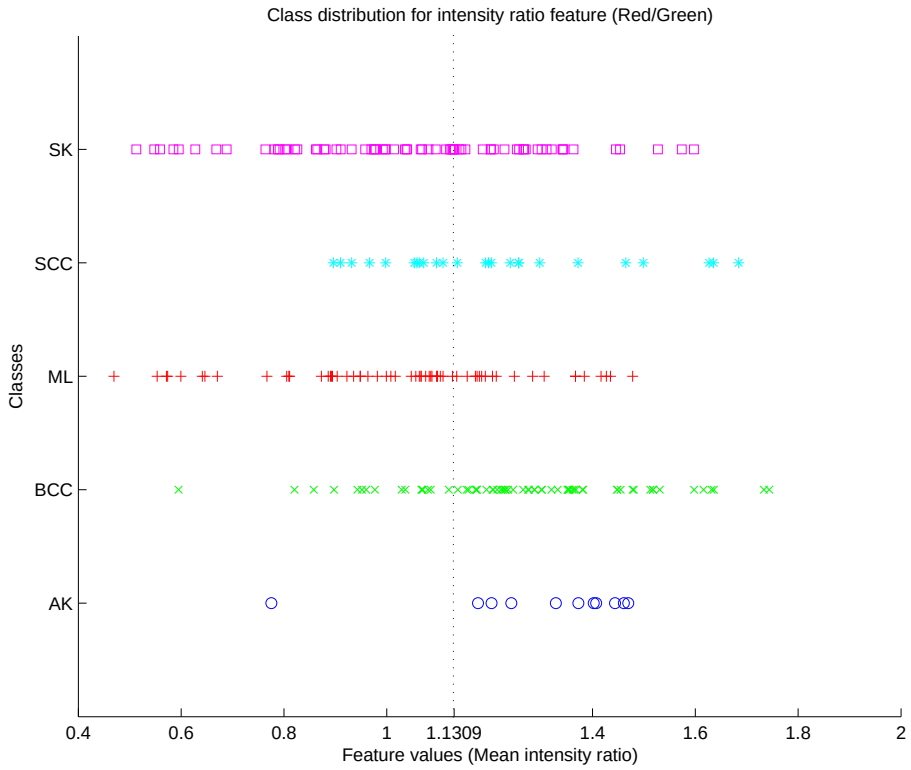
SK - Seborrhoeic Keratosis

Most previous research on melanoma only

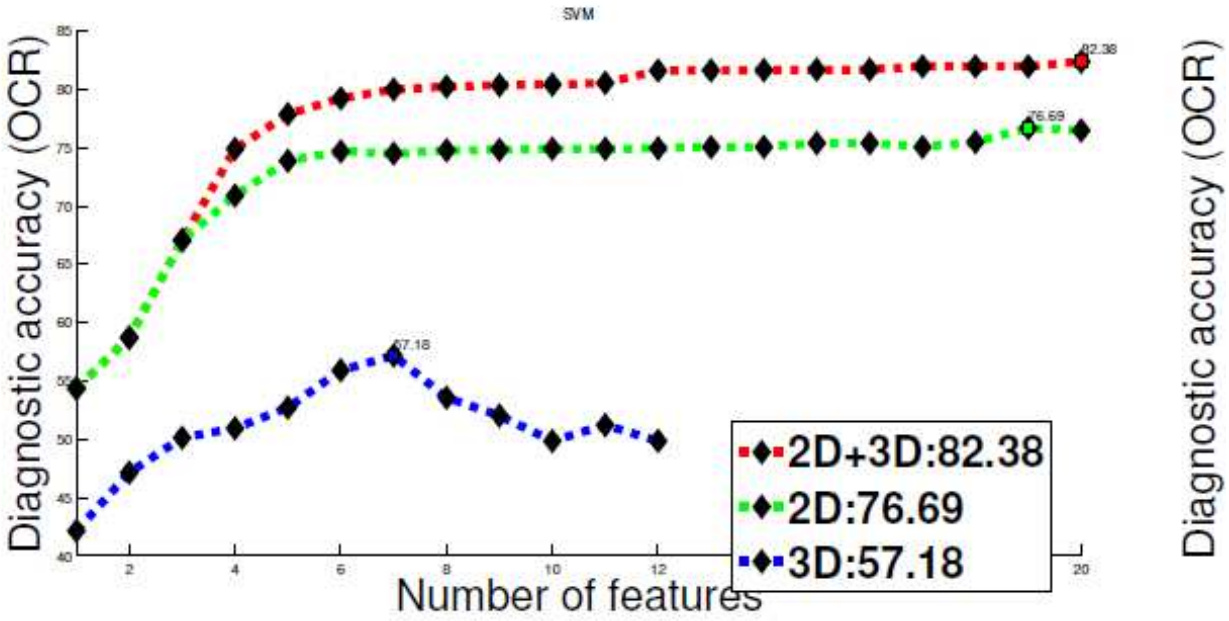
Skin Cancer Classification Adding Depth

About 50 properties including color, texture, depth

Feature 5: (mean green in lesion)/(mean red in normal)



Experiments (smaller dataset)



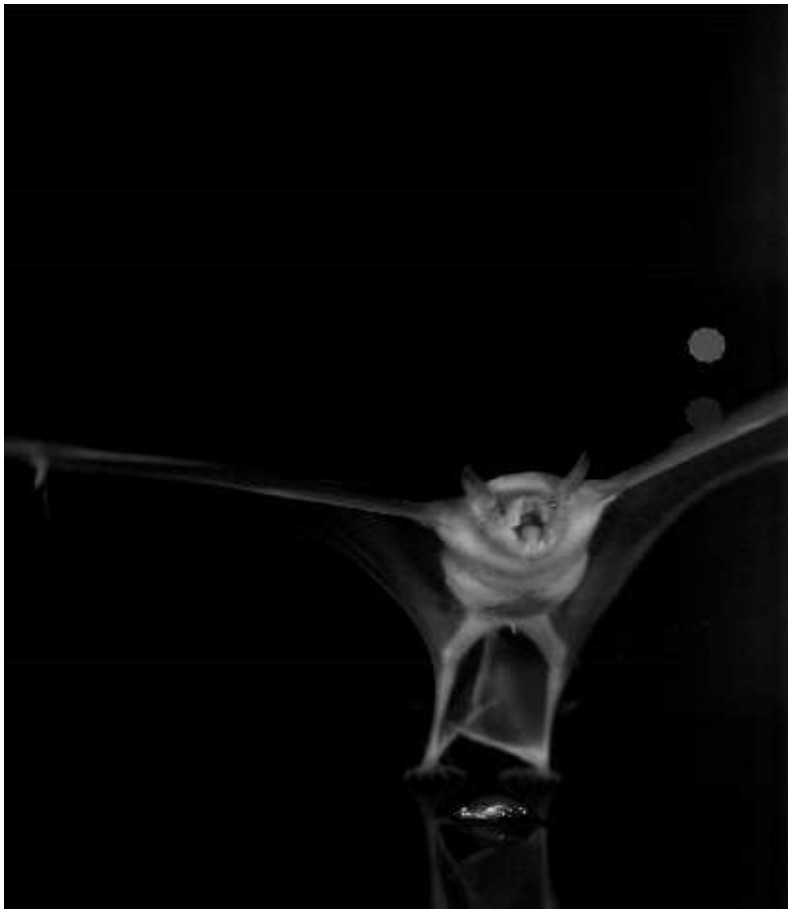
	Spec	Sens	Acc (OCR)
Color + texture	0.93	0.62	77%
Color + texture + depth	0.95	0.69	82%

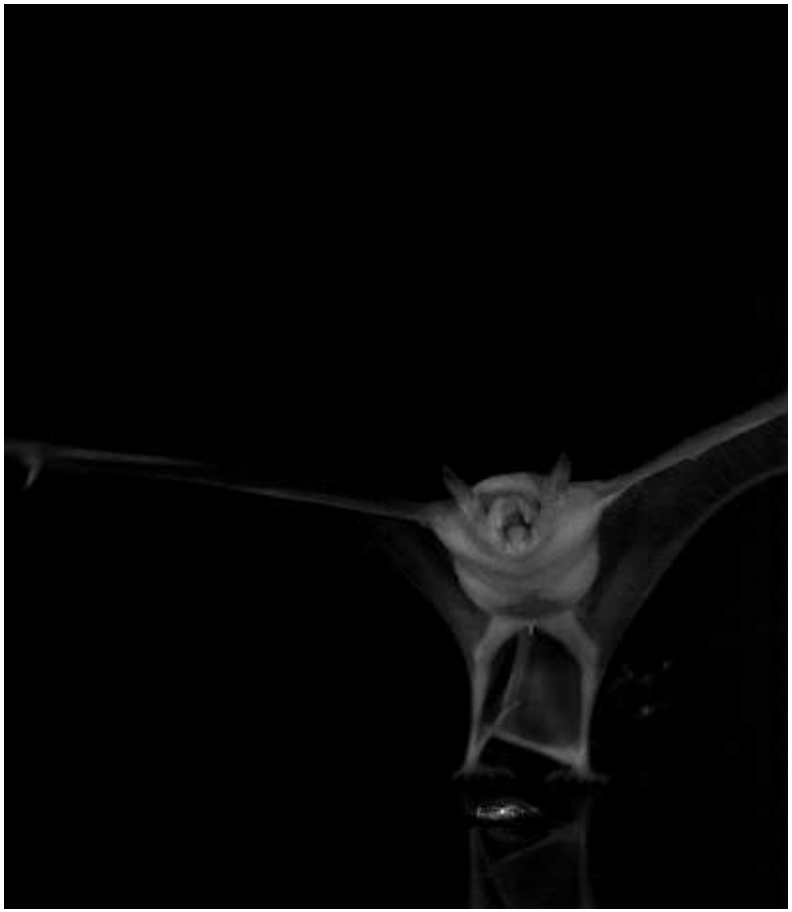
(Significant at p=0.0002 for adding depth)
First study on non-melanoma diagnosis (which is $> 90\%$ on melanoma after 25 years research *versus* 82% here after 3)

Application 1 Summary

- Depth data improves lesion segmentation and classification, but may not be economic
- Long way to go to melanoma *versus* mole's 90+% accuracy using specialized devices & 25 years research

High speed 3D video of bats





Yijun Xiao

High Speed Stereo 3D Capture

Dimensional Imaging stereo camera system

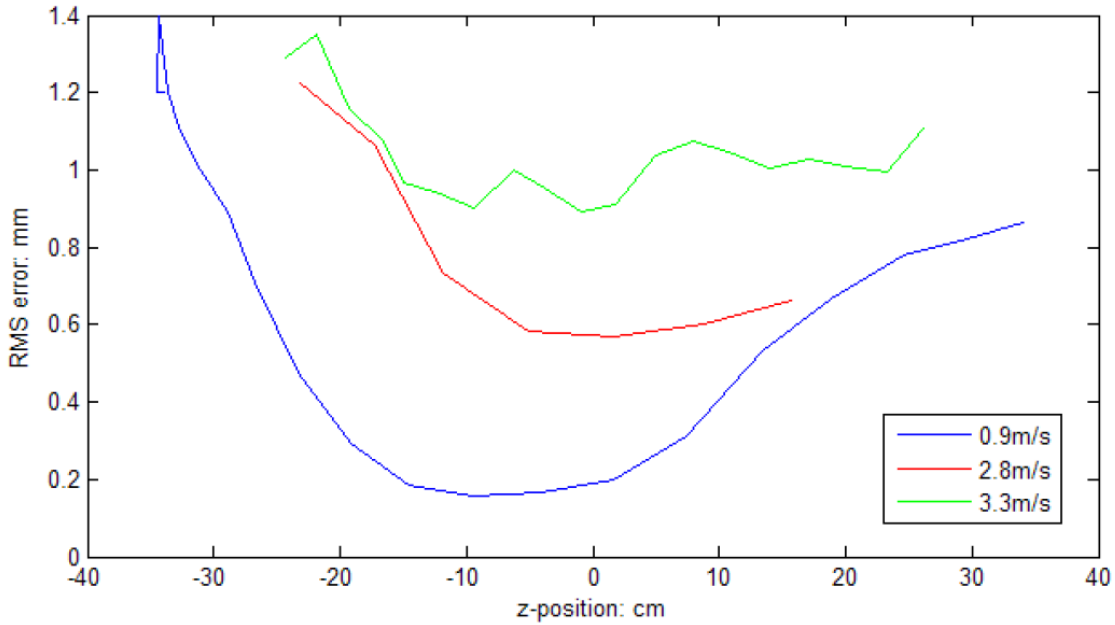
Unique custom designed sensor

500 Frames per second, 1.3 Mpix/frame, 2 seconds

Infrared sensitive cameras + infrared light panels

Post-capture 3D dense stereo calculation

Moving Target Performance



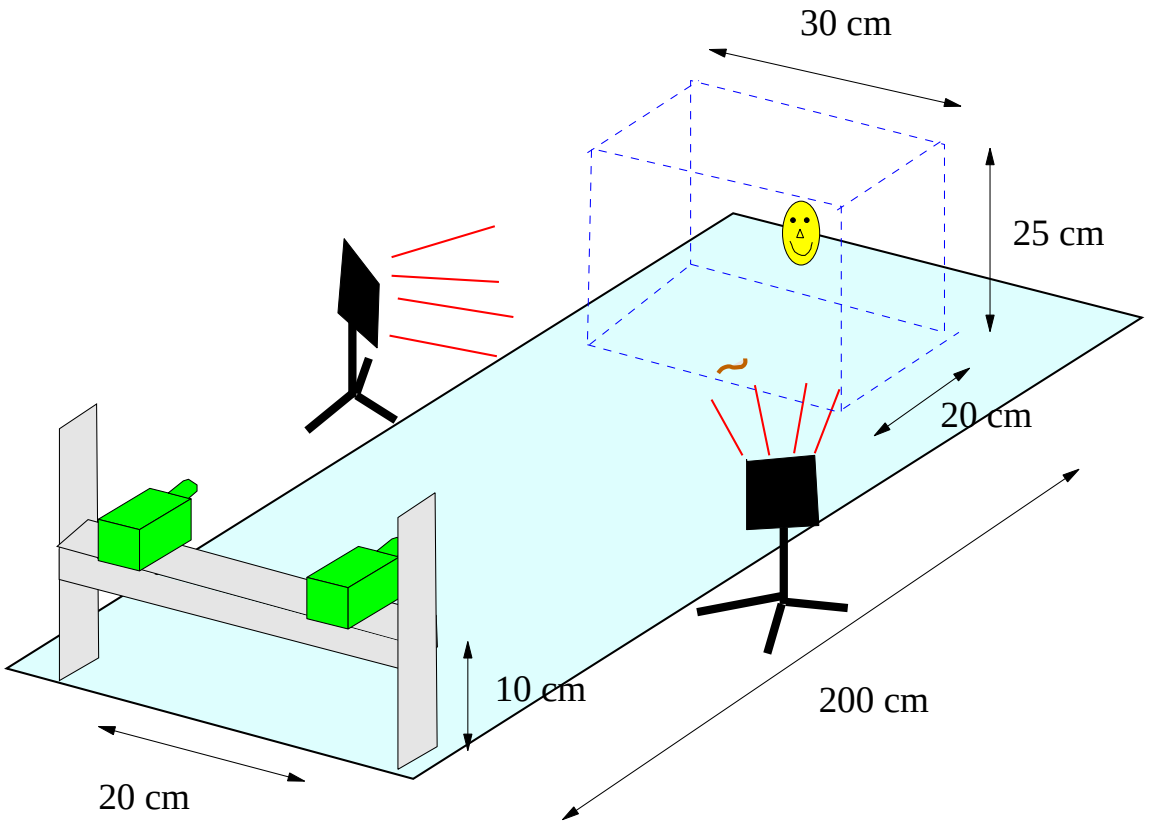
RMS 0.2 - 1.0 mm for looming speeds up to 3.3 m/s

RMS 0.75 mm for vertical speeds up to 5 m/s

RMS 1.4 mm for horizontal speeds up to 2.8 m/s

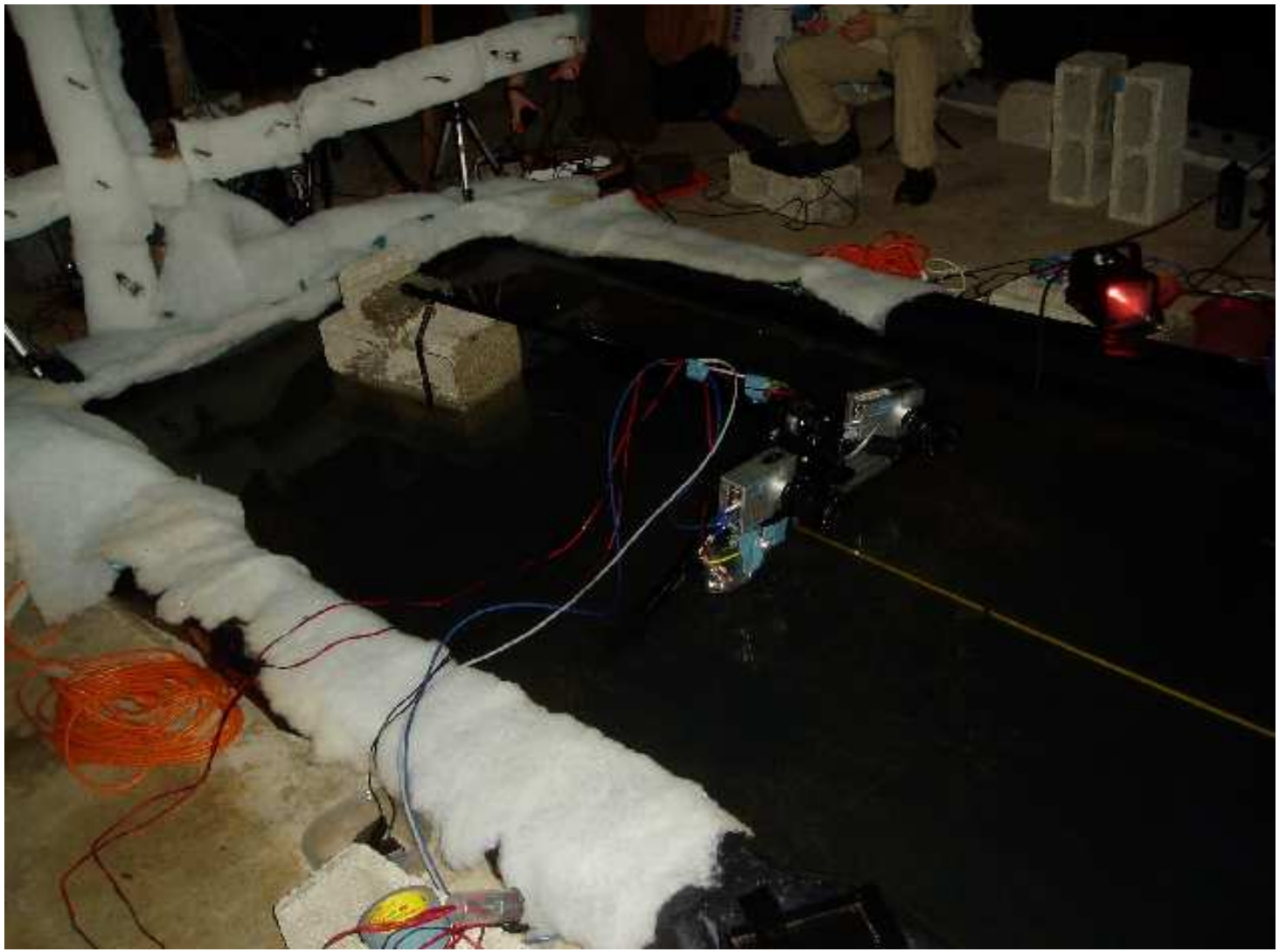
RMS 0.15 mm over 20 cm depth of field for static targets

Trawling data capture scheme



Bat data capture I

Bat data capture II

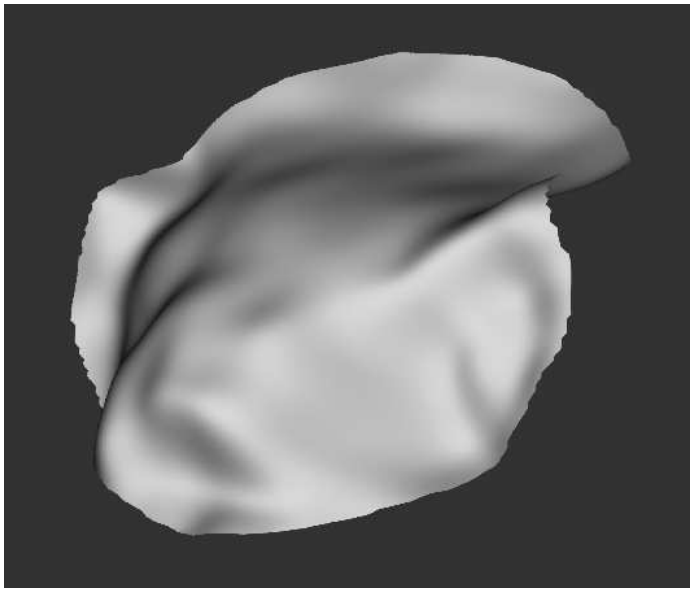


Stereo Bat Video

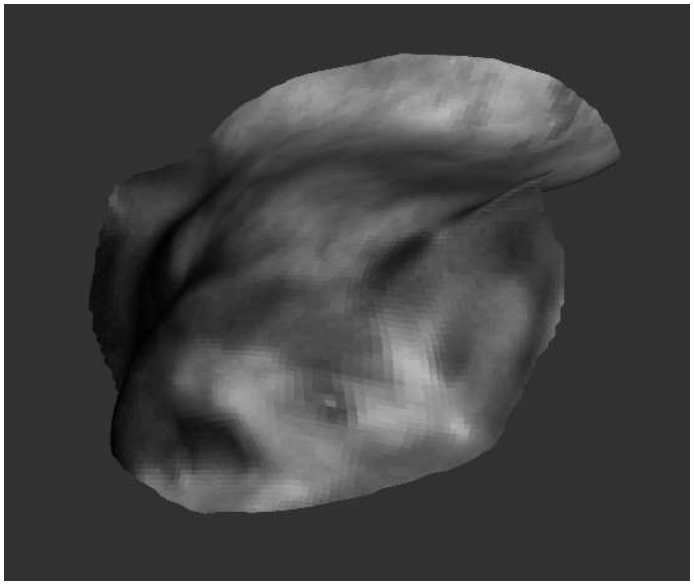
2009_03_21_Session5

3D bat: 3D_flying_bat

Bat data 3D surface capture

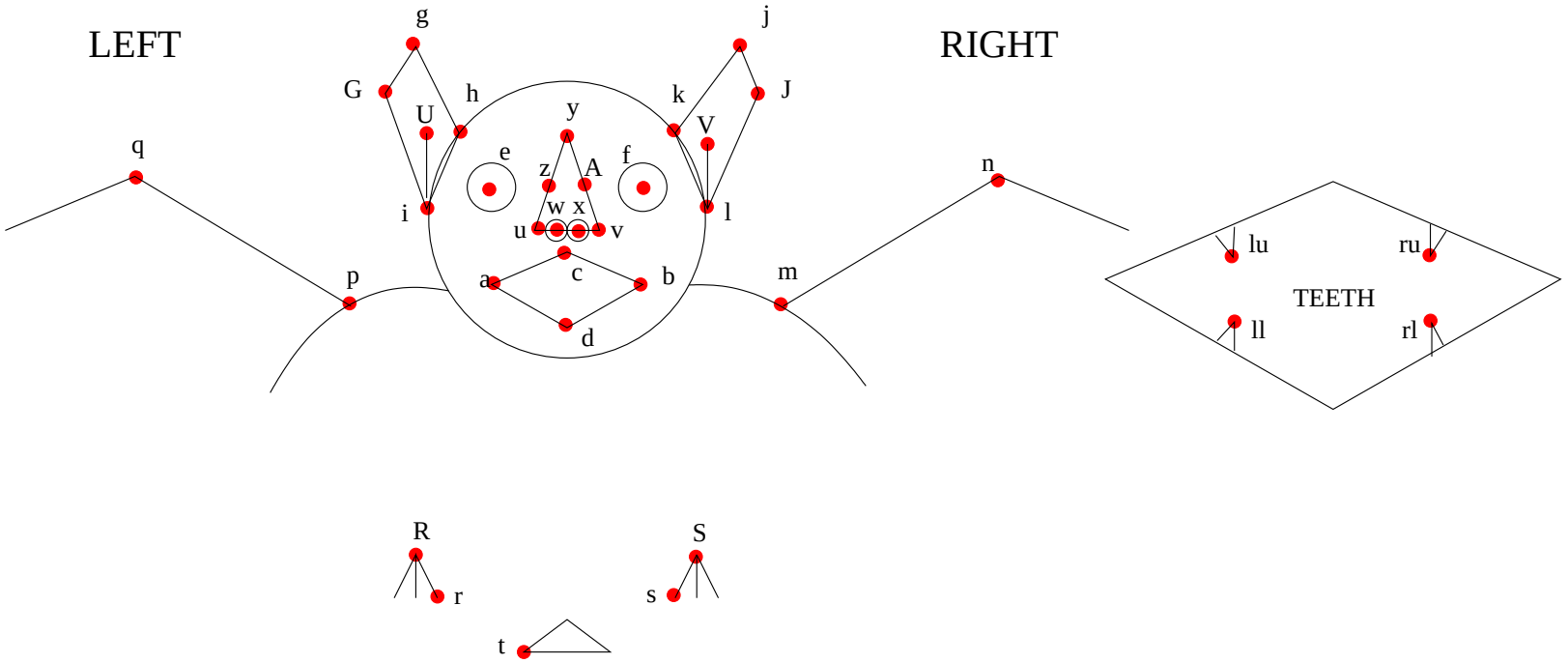


Cosine shaded 3D



Texture mapped

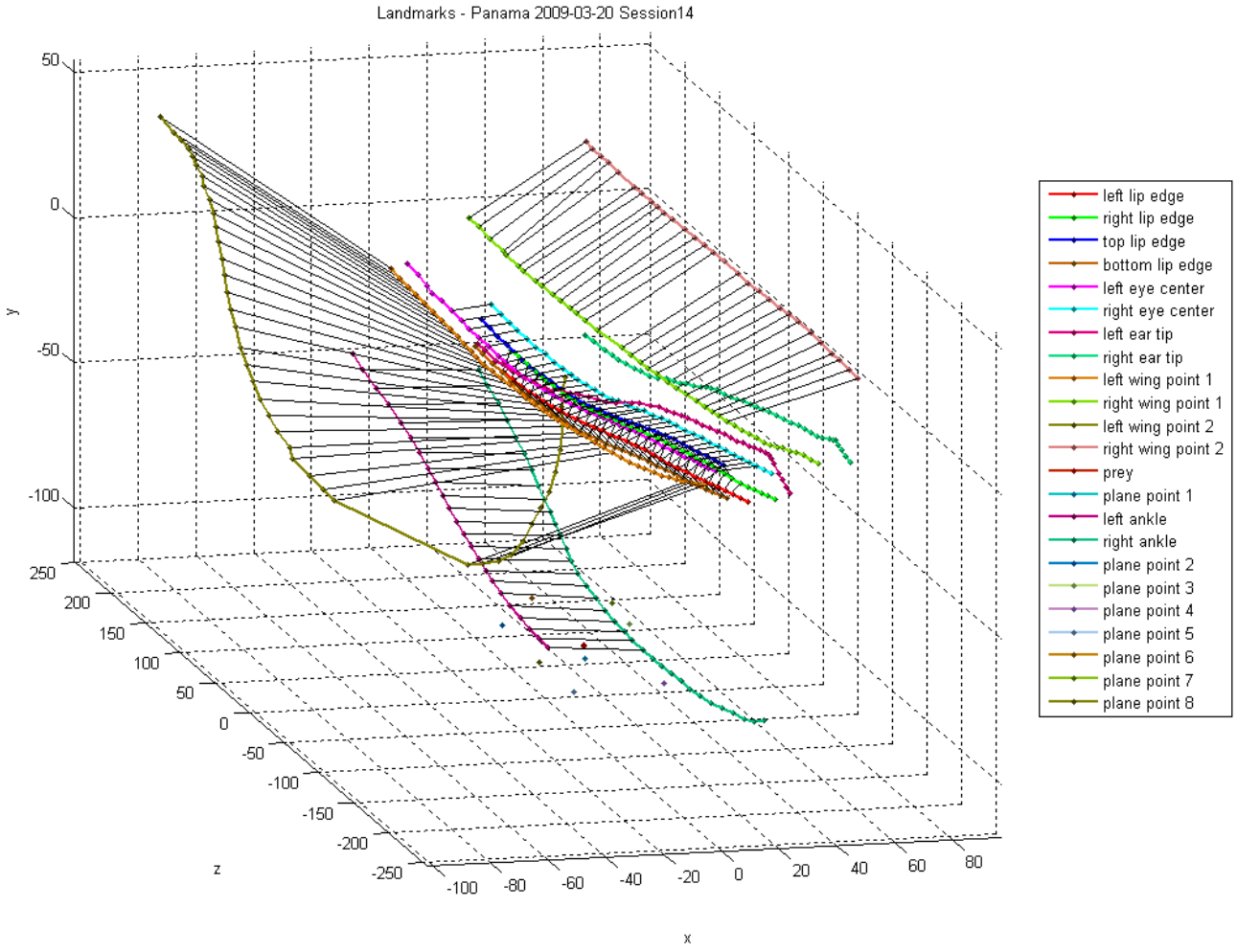
Bat Sequence Interesting Points



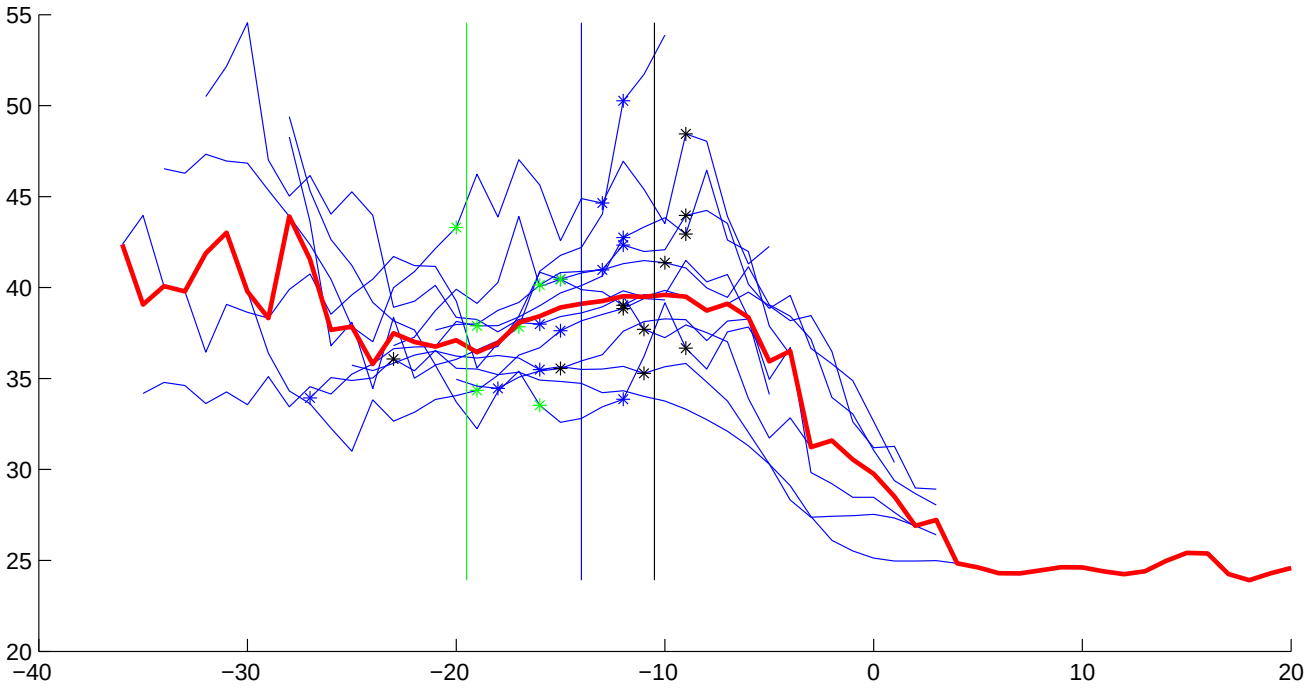
Up to 36 points *2 per frame

Computer-assisted markup

3D Tracked Points over Time



N. leporinus Ear Tip Separation



Lola, 13 runs (blue), median (red), prey contact at 0

Observation: ears elevate as bat starts new search calls

Application 2 Discussion

1. Goal: link 3D data of bat's behaviour during target acquisition: head, ear and nose leaf orientation, mouth opening, head shape to acoustic behaviour
2. ChiRoPing EC project: build better robot acoustic sensor
3. 500 FPS sensor + software gives useful 3D data, but needs more extension to get more surface detail + smooth temporal data

Conclusion

1. Novel 3D sensing enables new ways to look at problems
2. Explosion of 'Kinect' applications
3. Expect many more: surveillance, monitoring, performance assessment, ...