

## Prediction of Future Major Adverse Cardiac Events: Coronary IVUS

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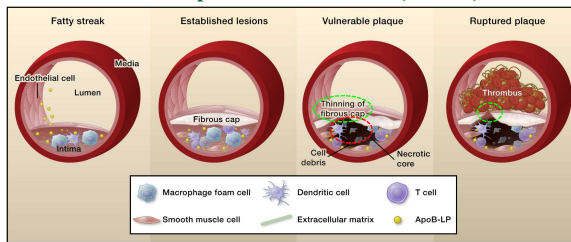
## Cardiovascular Precision Medicine

- Cardiology at forefront of quantitative analysis for decades
  - QCA – 1980's
- Cardiovascular **imaging** is everywhere
  - Angio, IVUS, MR, CT, SPECT, OCT, ...
- Image **analysis** for clinical care is still mainly qualitative
- Quantification needs to be omnipresent in routine clinical care for precision medicine to reach its potential

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## Do you remember this slide? ... Thin-Cap Fibroatheromas (TCFA)



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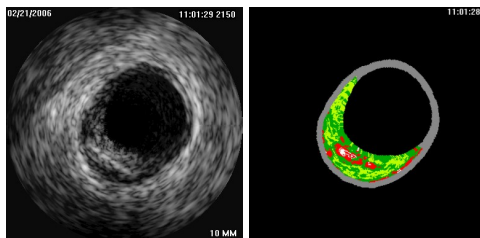
## MACE Risk – Major Adverse Cardiac Events

- High-risk coronary plaque:
  - Thin-cap fibroatheroma (TCFA)
  - Plaque burden PB>70%
  - Minimal luminal area MLA<4mm<sup>2</sup>
- MACE prevention:
  - Identify locations at risk to develop high-risk plaques
  - Intervene (balloon angioplasty, stenting, medication, ...)

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## IVUS + Virtual Histology



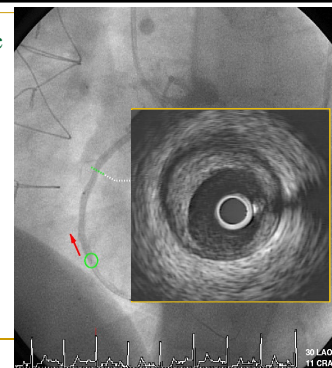
- White = Dense Calcium
- Dark Green = Fibrous (Fibro-fatty)
- Red = Necrotic Core
- Light green = Fibro-lipidic

Demo: Virtual histology – VRML visualization

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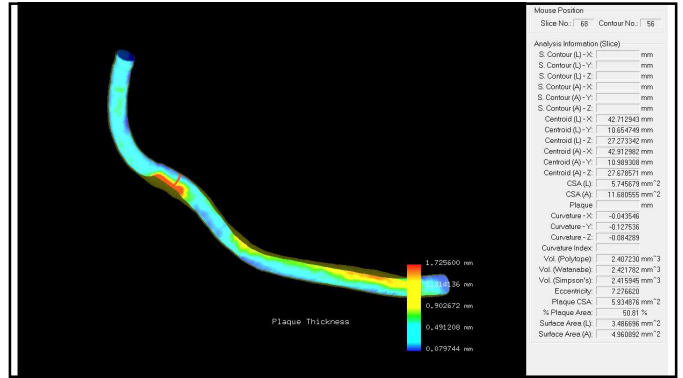
Angiographic Lumen

Intravascular Ultrasound



### IVUS Image Segmentation

- LOGISMOS approach for simultaneous dual-surface segmentation
- User-guided computer-aided refinement (Just-Enough Interaction)
- User interaction time reduced from hours to several minutes



### Can Future TCFA Locations be Predicted? Can MACE be Predicted?

1 year later

What will happen here?

TCFA

NonTCFA

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### Study Cohort

- 61 patients with stable angina pectoris
- 2 studies comparing statin therapy for atherosclerosis progression
- Plaque types (truth) →

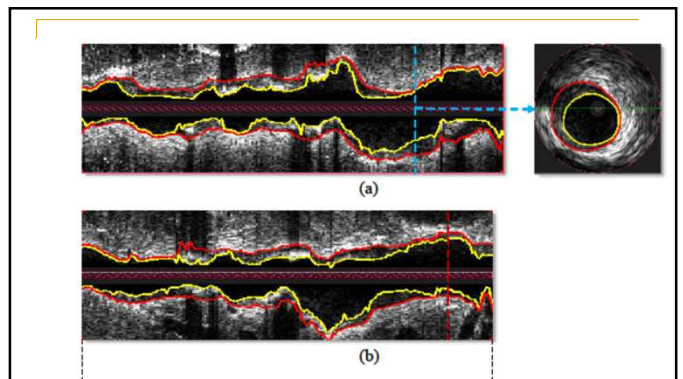
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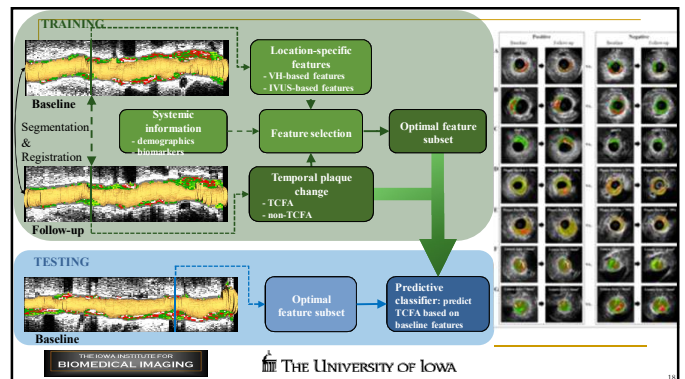
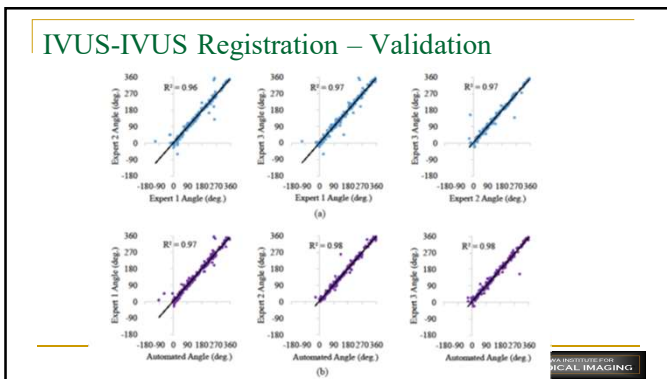
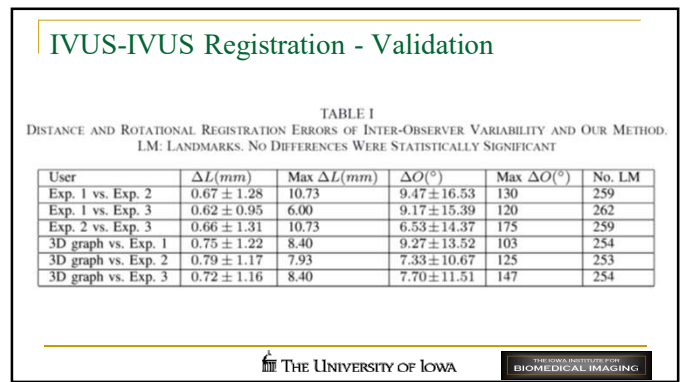
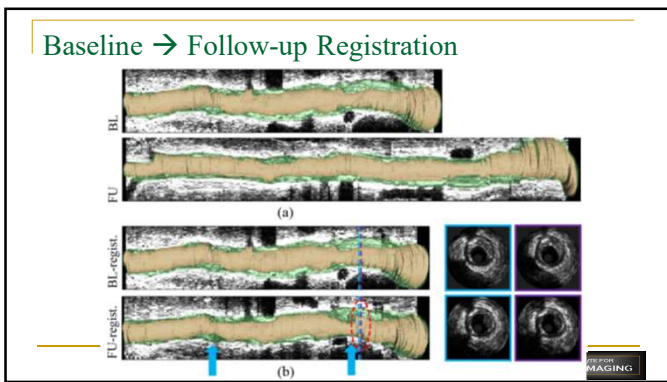
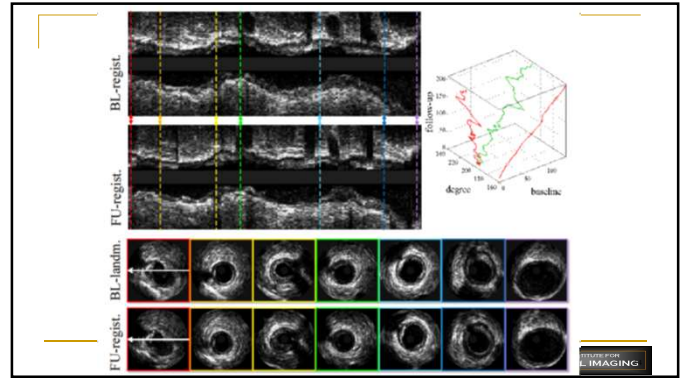
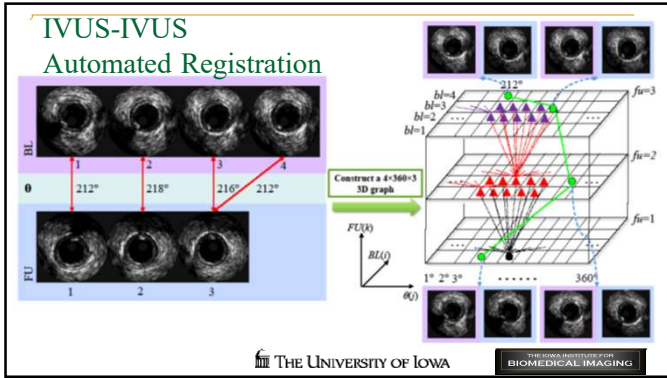
### Predicting Plaque Development

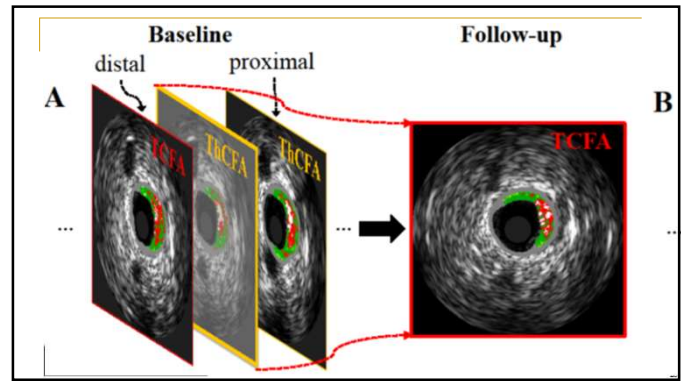
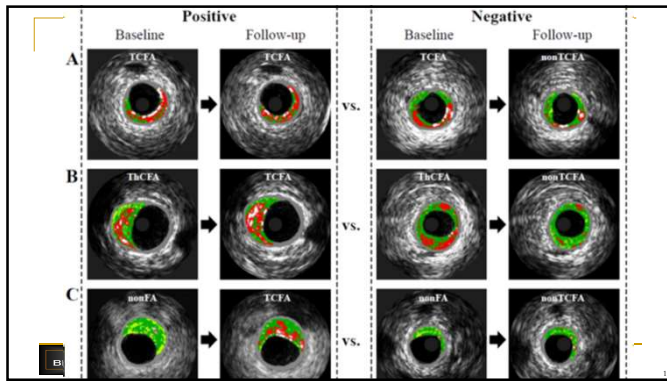
**TRAINING of classifier to predict changes in a single variable of temporal plaque change**

**PREDICTION of plaque changes and performance assessment using a trained classifier**

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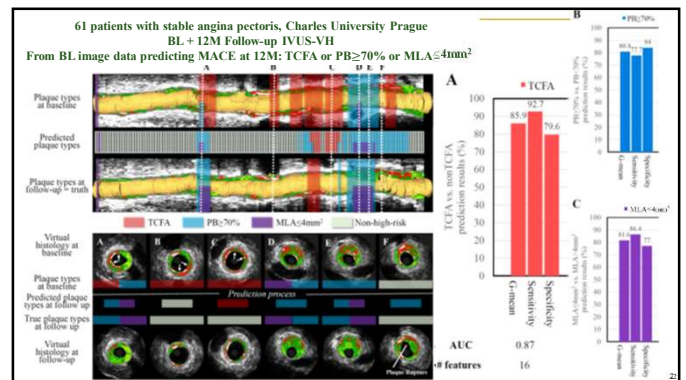


### Feature Set

<b>Basic Measures (F1-F21)</b>	<b>Clinical</b>	<b>Plaque composition:</b> DCNC/FFFT [%], max. confluent NC, max. NC angle, # NC abutting	<b>Plaque phenotype:</b> [CSA], DCNC/FFFT [%], max. confluent NC, max. NC angle, # NC abutting
<b>First-Order Descriptors (F22-F30)</b>	<b>Plaque morphology:</b> Lumen/EEM/PM [CSA], PB, remodeling index, distance to ostium, mean plaque thickness, std. plaque thickness, eccentricity	<b>Plaque grayscale intensity:</b> mean, median, std., max, min, mode	<b>Plaque intensity histogram:</b> first, median, third quartiles
<b>Plaque Textures (F31-F46)</b>	<b>Layered Components (F47-F118)</b>	<b>Contrast, correlation, energy, homogeneity</b> [ $\theta = 0^\circ, 45^\circ, 90^\circ, 135^\circ$ ]	<b>DCNC/FFFT [%]</b> in 10%-90% inner & outer rings.
<b>Spatial Contextual Features (F119-F236)</b>	<b>Average feature value of one adjacent distal and one adjacent proximal frames. Calculate for all F1-F118.</b>	<b>Systemic Demographics &amp; Biomarkers (F237-F254)</b>	<b>Age, gender, weight, BMI, family history, smoking history, current smoker, hypertension, diabetes, hyperlipidemia, previous MI, beta-blockers, ACE inhibitors, previous statin treatment, total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides.</b>

DC: dense calcium; NC: necrotic core; FF: fibrofatty; FT: fibrotic tissue; BMI: body mass index; MI: myocardial infarction; ACE: angiotensin-converting enzyme; LDL: low-density lipoprotein; HDL: high-density lipoprotein.

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### Results: Plaque Type Development (w Statins)

Baseline		Follow-up					
		TCFA	ThCFA	FeP	FP	PIT	NL
TCFA	408 (6%)	55	148	13	109	71	12
ThCFA	1068 (17%)	36	390	59	205	277	101
FeP	140 (2%)	2	45	32	12	35	14
FP	826 (13%)	4	108	19	314	279	102
PIT	2005 (32%)	17	128	20	719	881	240
NL	1894 (30%)	10	51	18	86	196	1533
Total	6341	124 (2%)	870 (14%)	161 (3%)	1445 (23%)	1739 (27%)	2002 (32%)

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### Conclusion

- Prerequisites to precision medicine in atherosclerosis
- Highly accurate quantitative analysis of coronary morphology
  - Relevant biomarkers
  - Longitudinal data
  - Large-enough dataset with ground truth
  - All is challenging
    - Requires Engineering – Medicine collaboration
    - Frequently multi-center data acquisition
  - And it is costly
- The potential rewards are worth the effort!**

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