

# Visual Feedback for Skill Acquisition in Cataract Surgery

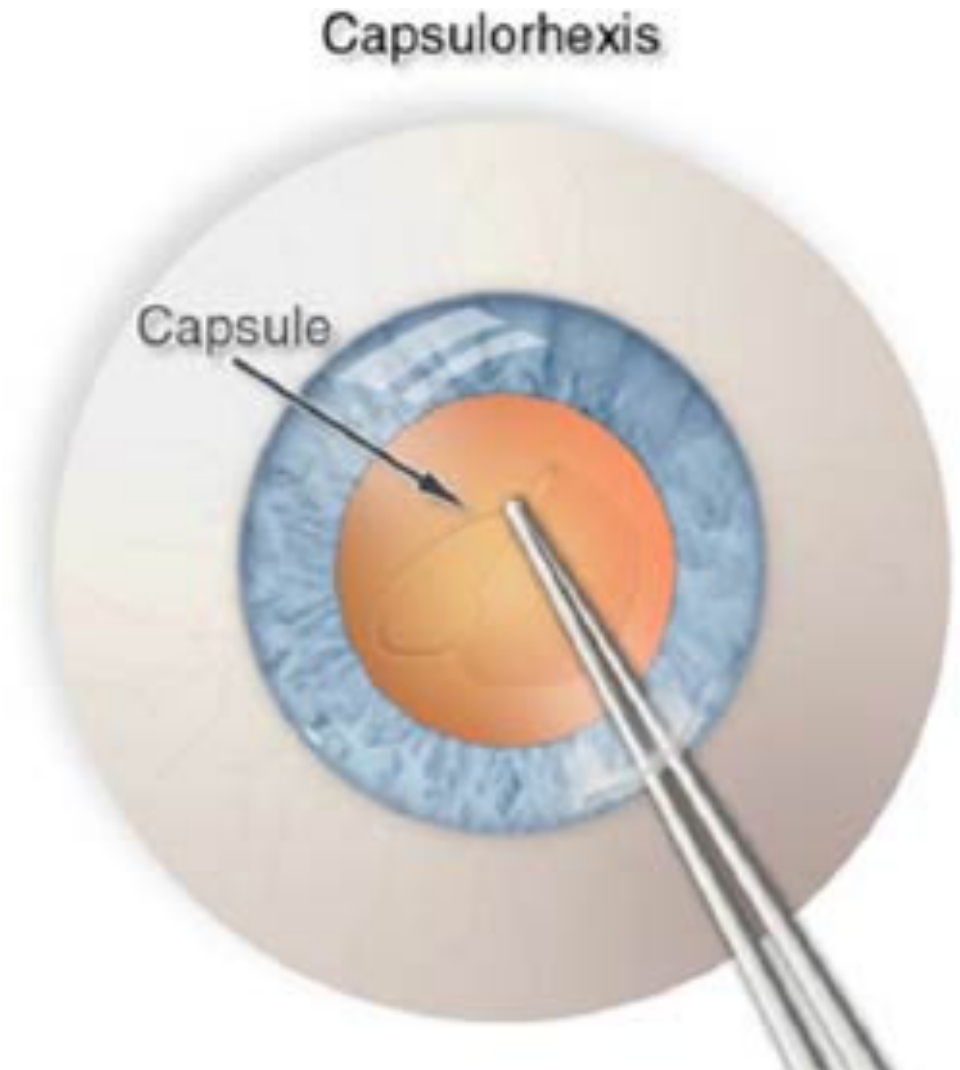
Group: 22

Group Members: Abhilash Balachandarn

Mentors : Swaroop Vedula, Austin Reiter

# Capsulorhexis

Removal of lens during  
cataract surgery



# Motivation And Background

- Current skill feedback used predominantly is in the form of instruction.
- Not automated.
- Need to develop systems that can accurately predict expertise
- Train novices
- Record tool motion and force patterns to compare between novices and experts

# Kinematic Analysis of Surgical Dexterity in Intraocular Surgery

*George M. Saleh, FRCS, FRCOphth; Dan Lindfield, MRCOphth; Dawn Sim, MRCOphth; Elena Tsesmetzoglou, MRCOphth; Vinod Gauba, FRCOphth; David S. Gartry, FRCOphth; Salim Ghousayni, PhD*

**Objective:** To evaluate the potential of motion analysis as a discriminator of surgical skill during intraocular surgery.

**Methods:** Twenty-four subjects were divided into 3 groups ( $n=8$  each) based on the number of completed phacoemulsification procedures: novice ( $n<10$ ), intermediate ( $n=10-150$ ), and expert ( $n>150$ ). The Qualisys motion-capture system obtained data from the surgeons performing (1) corneal wound construction (incision), (2) continuous curvilinear capsulorhexis (CCC), and (3) phacoemulsification lens extraction on artificial eyes. The main outcome measures were time, overall path length, and total number of movements. Statistical significance was set at  $P<.05$ .

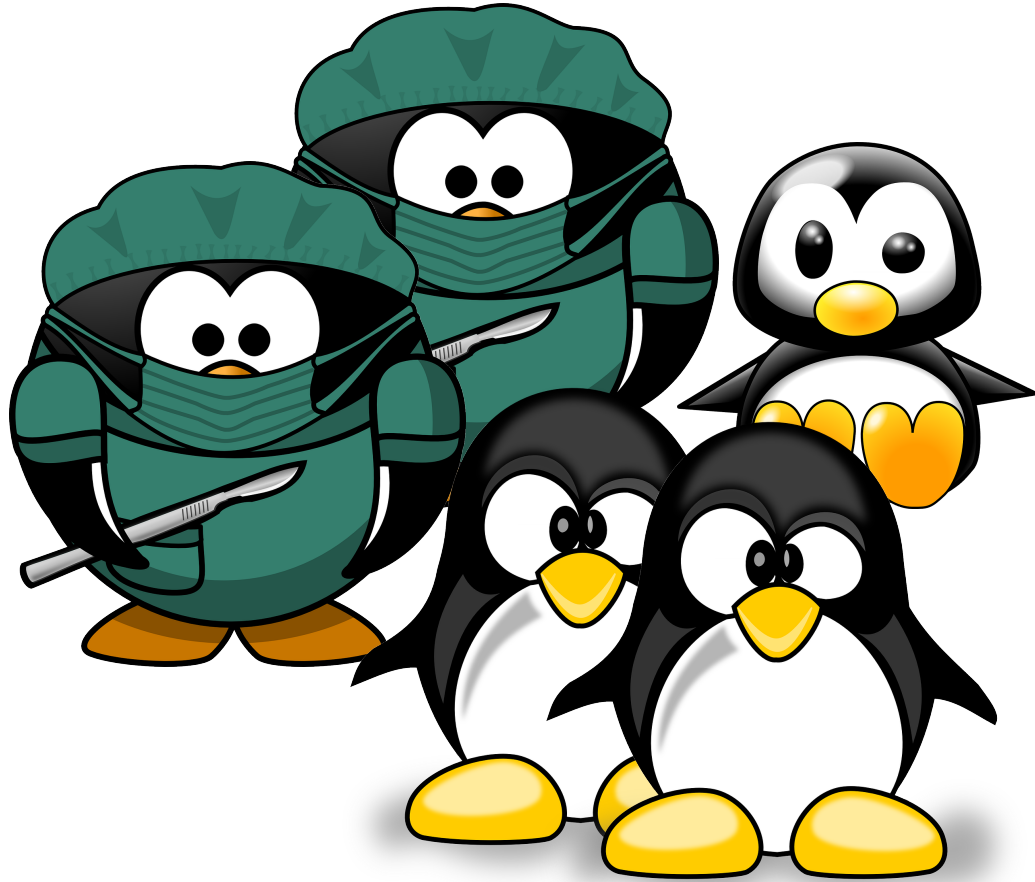
( $P=.001$ ), number of movements ( $P=.001$ ), and path length ( $P=.05$ ). For the CCC task, significant differences were found between groups for time ( $P=.03$ ) and number of movements ( $P=.03$ ), but not for path length ( $P=.08$ ). For the phacoemulsification task, significant differences were found between the 3 groups for time ( $P=.04$ ), path length ( $P=.02$ ), and number of movements ( $P=.04$ ).

**Conclusions:** Motion analysis differentiated between surgeons with varying levels of experience performing phacoemulsification tasks, thus demonstrating construct validity. This technique may be useful in the objective quantitative measurement of microsurgical skill with potential applications for training and research.

# Objective:

- evaluate the potential of motion analysis as a discriminator of surgical skill during intraocular surgery.
- Particularly a technique known as phacoemulsification

# Method



24 subjects into 3 groups

Expert >150 procedures



Intermediate 10-150

Novice < 10 Procedures

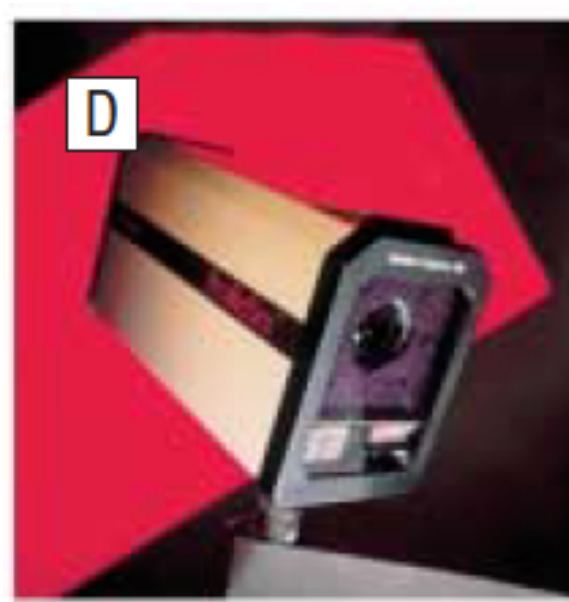


# 3 Tasks

- Construction of a standard 2 step incision
- Anterior chamber re-formation of artificial eye
- Complete removal of lens nucleus

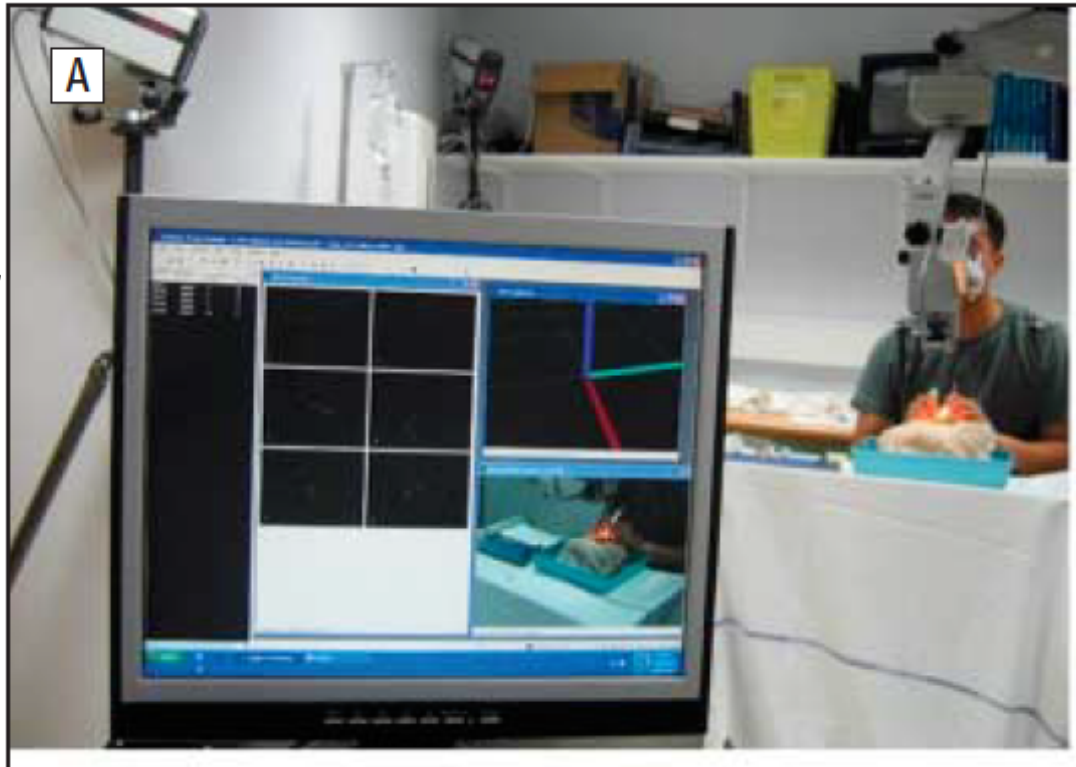
# Experimental Setup

- The 6-camera Qualisys ProReflex system



# Experimental Setup

- with motion capture units carefully positioned to cover the measurement volume and minimize occlusion due to body parts, tools, and instruments



retroreflective  
markers used  
to track hand  
motion

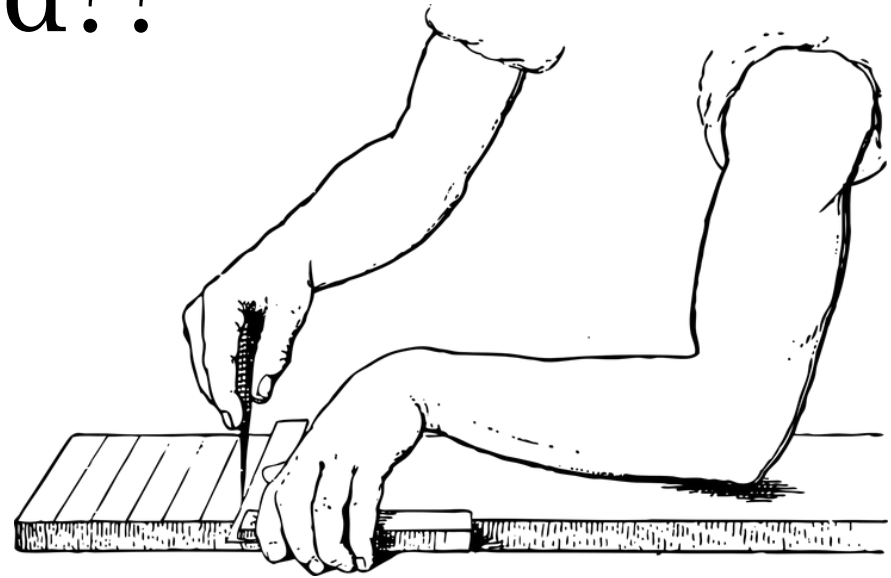
# Experimental Setup

- The marker locations were selected to track both finger and hand segment motion in 3 dimensions and, at the same time, minimize encumbrance to the subject.
- Four markers were attached per hand .Size and placement of markers were determined following extensive pilot laboratory work calibrating the instrument for ophthalmic use

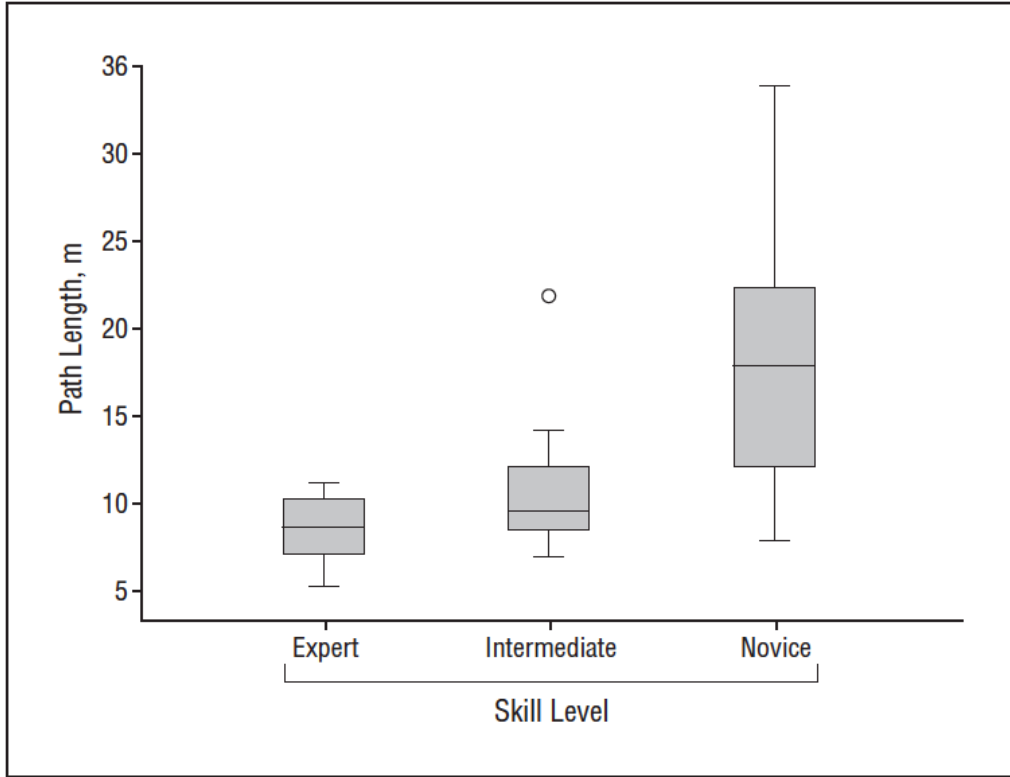


# Parameters measured??

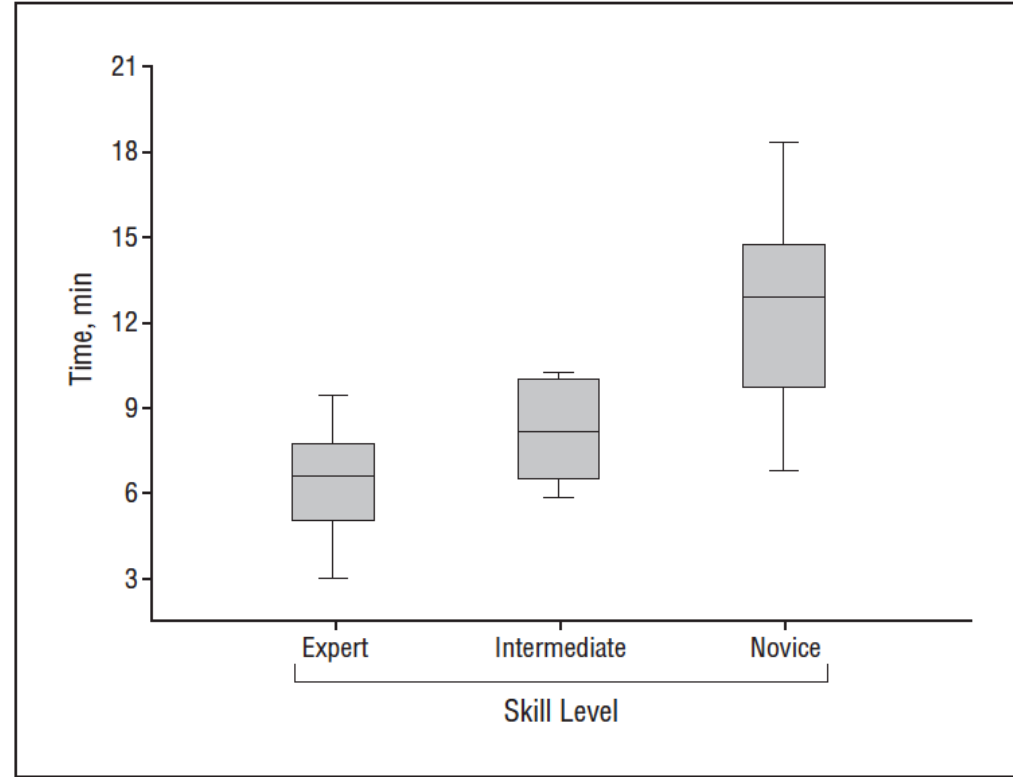
- the time taken,
- the total path length covered, and the
- total number of movements to complete the surgical task.



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Box plot showing the overall path length (in meters) covered by each of the 3 groups to complete the 3 tasks. The circle indicates an outlier



Box plot showing the time taken (in minutes) by each of the 3 groups to complete the 3 tasks.

P value



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# P value

- a  $p$ -value helps you determine the significance of your results that is the probability, called  **$p$  value**
- which leads us to reject or accept the **hypothesis**
- A  $p$  value  $p < 0.05$  is often considered significant, but the lower this figure, the stronger the evidence.



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# As numbers

| P value | Criteria    |
|---------|-------------|
| 0.01    | Time        |
| 0.01    | Movements   |
| 0.05    | Path length |

# Conclusions

as experience increased there was a reduction in the variability between the individuals within the cohort, perhaps suggesting that surgical skill may converge to a narrower spread of efficiency that all trainees should be aspiring toward.

# Limitations

- Artificial eye used
- Not the whole procedure but rather certain specific steps of importance
- Costly equipment
- Hand motion rather than tool motion is evaluated

## “PhacoTracking”

### *An Evolving Paradigm in Ophthalmic Surgical Training*

*Phillip Smith, BSci; Lilian Tang, BEng, MEng, PhD (Cantab); Vassilis Balntas, MSc, MEng;  
Karen Young, PhD, CStat; Yannis Athanasiadis, MD, MRCSEd; Paul Sullivan, FRCS, FRCOphth;  
Badrul Hussain, FRCSEd, MRCOphth; George M. Saleh, FRCSEd, FRCOphth*

**M**otion analysis has been validated as a tool to evaluate surgical skill. We investigated a novel computer vision–based tool for the evaluation of surgical movements during cataract surgery. A prospective cohort analysis of 2 groups was performed. Ten videos of junior surgeons (ie, those with <200 cases) and 10 videos of senior surgeons (ie, those with >1000 cases) were analyzed. Movement parameters were measured over an entire procedure. Significant statistical differences were found between novice and expert surgeons for total path length ( $P=.002$ ), number of movements ( $P=.05$ ), and total time ( $P=.004$ ). Our study has shown that computer vision–based motion analysis can be successfully applied to video recordings of cataract surgery to provide robust measurements of instrument mo-

Tracking Methodology to  
phacoemulsification (a cataract  
procedure) cataract surgery



# PhacoTracking

<https://www.psychologytoday.com/blog/having-fun/201602/thinking-the-fun-it>

Tracking Methodology to  
photoemulsification (a cataract  
procedure) cataract surgery -> analyse  
instrument motion during procedure



# PhacoTracking

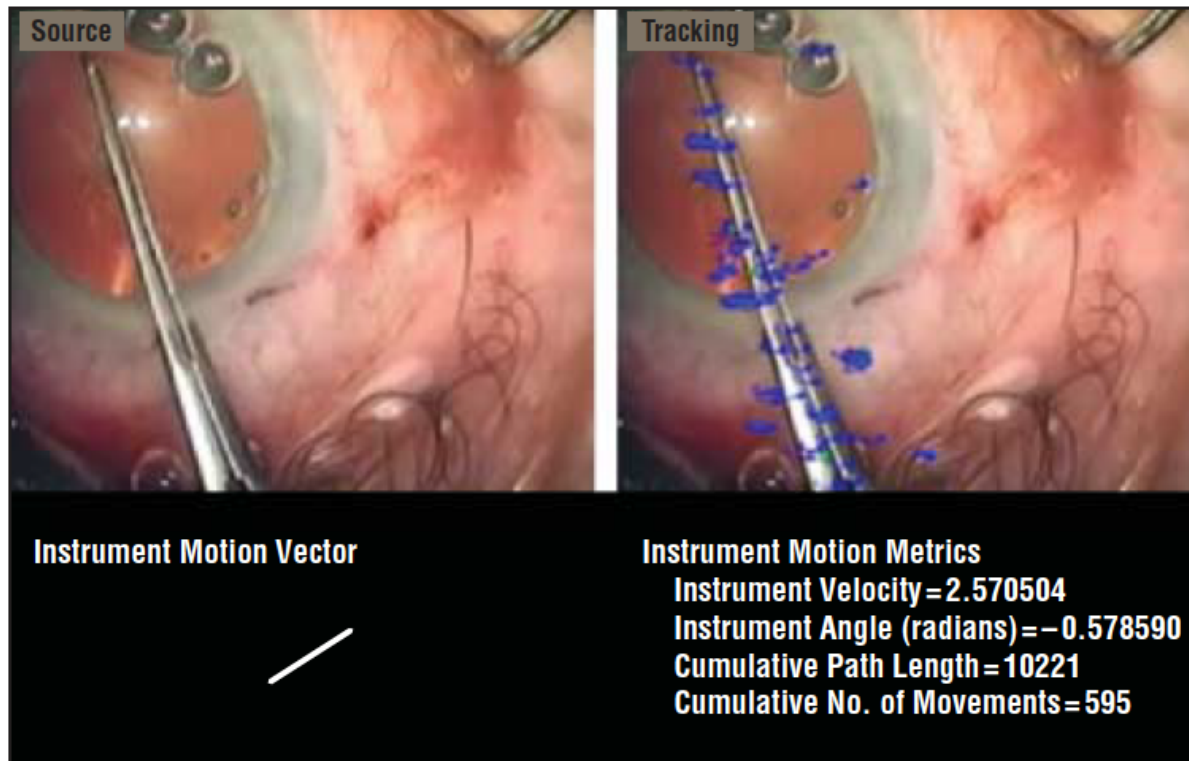
<https://www.psychologytoday.com/blog/having-fun/201602/thinking-the-fun-it>

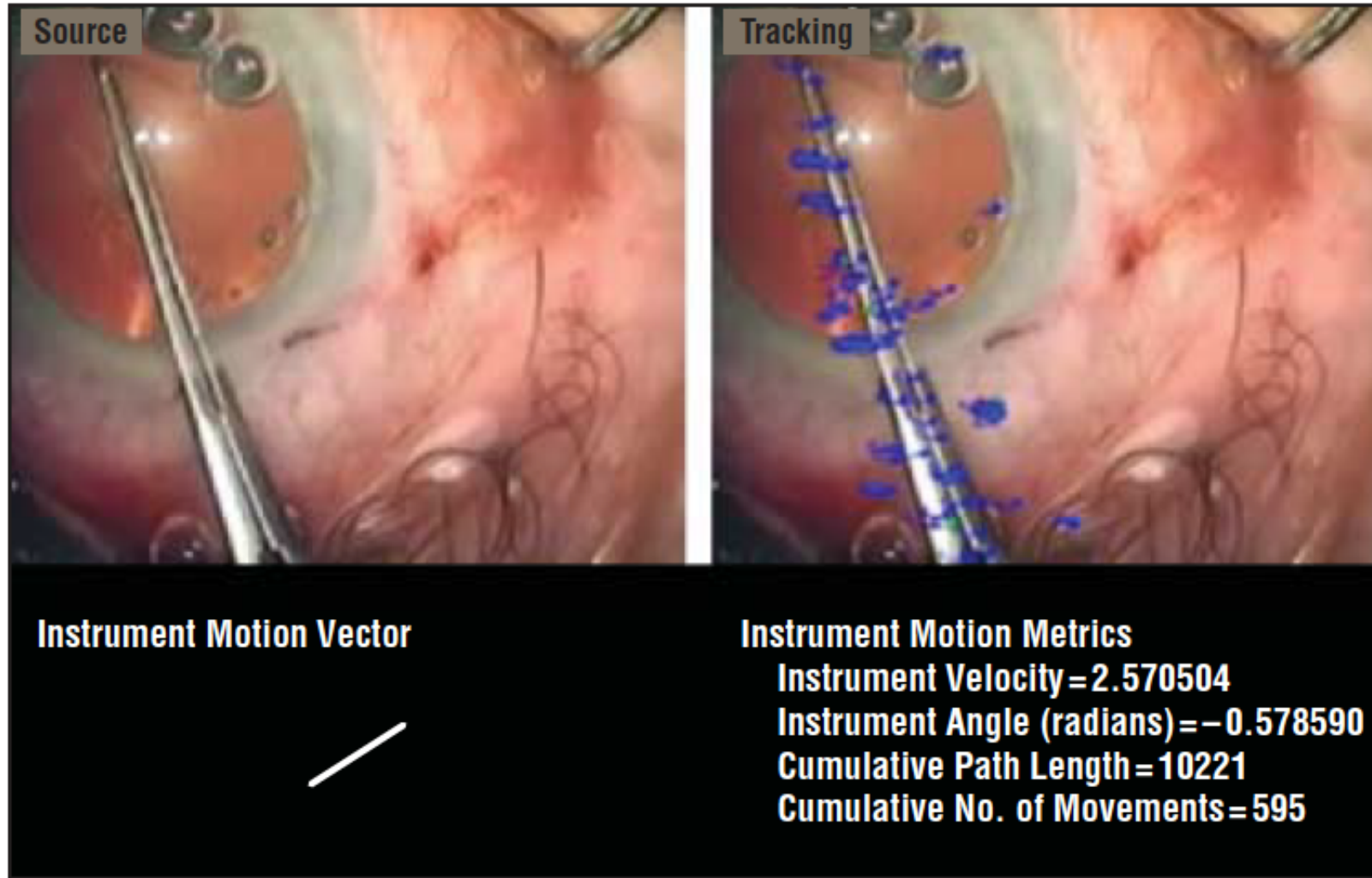
Tracking Methodology to  
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# PhacoTracking





Output from instrument tracking system. The top portion of the output shows the input video and the result of computer vision tracking. The lower portion shows the metrics that are measured by the system

# Two groups analyzed

Expert i.e >1000 cases



Novice i.e <200 cases



# Two groups analyzed

Expert i.e  $>1000$  cases



Novice i.e  $<200$  cases



10 videos in each group

# Data recorded

- Time
- Path Length
- Number of movements

# Some Conditions

- Only straightforward cases
- Pupils dilate, mild to moderate cataract
- Able to lie fully flat and still during surgery

## Excluded

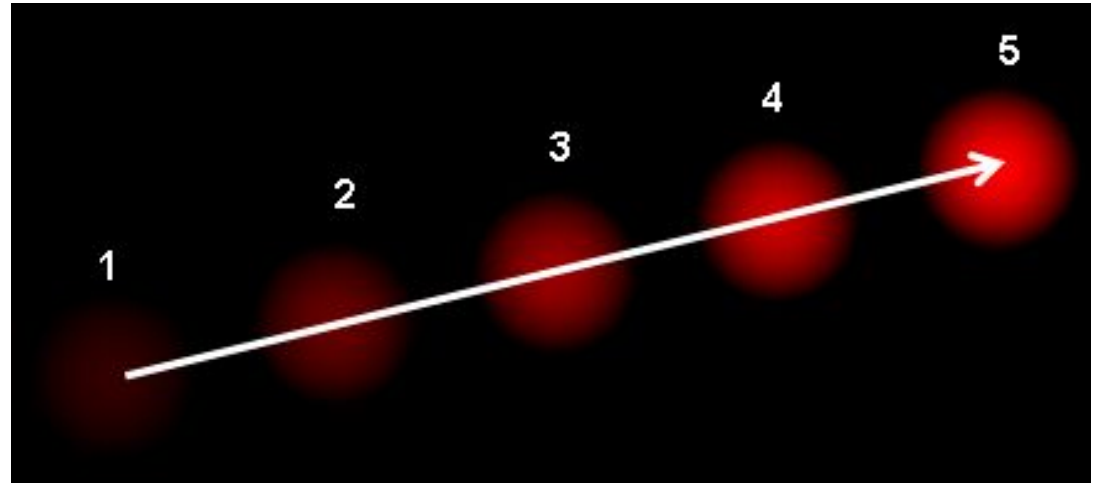
- Non routine cataract
- Unstable/critical patients

# How were the metrics measured

- Combination of Speeded Up Robust Features (SURF) (A.) detection and Optical flow (Lucas Kannade) (B.)



A.

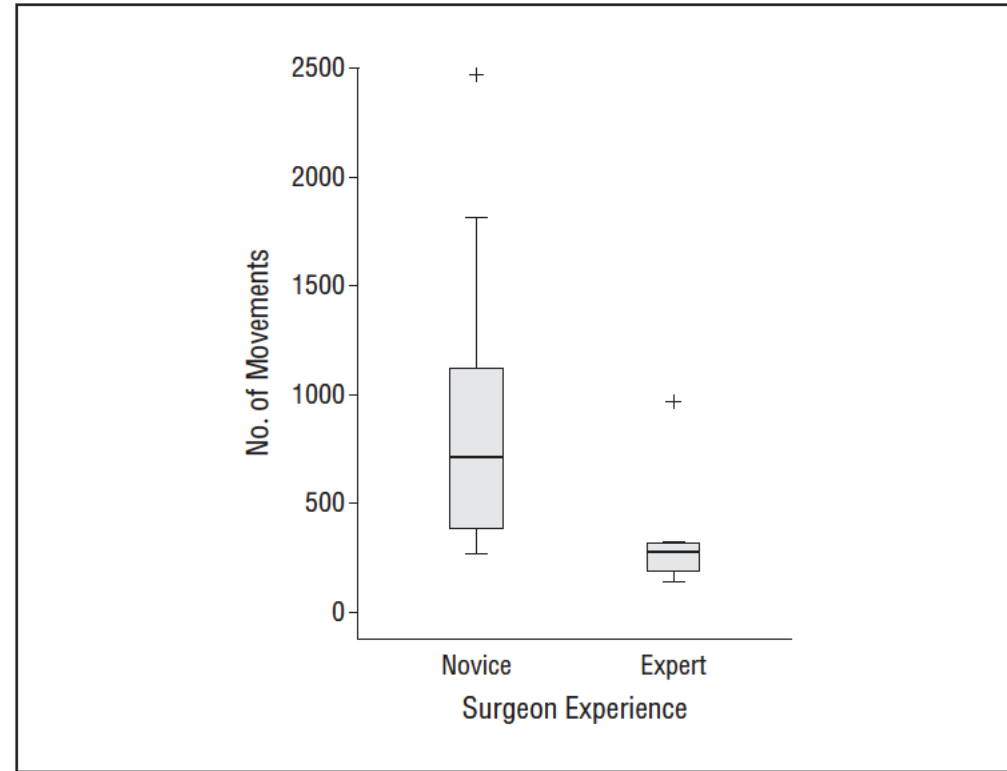
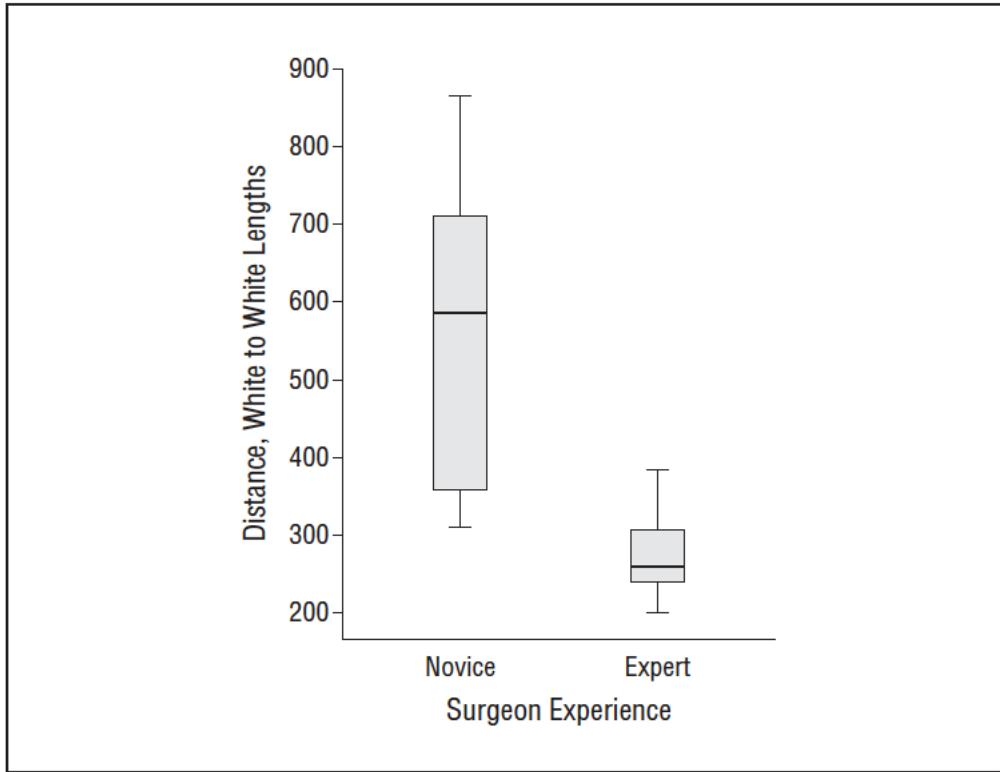


B.

# How the metrics were measured

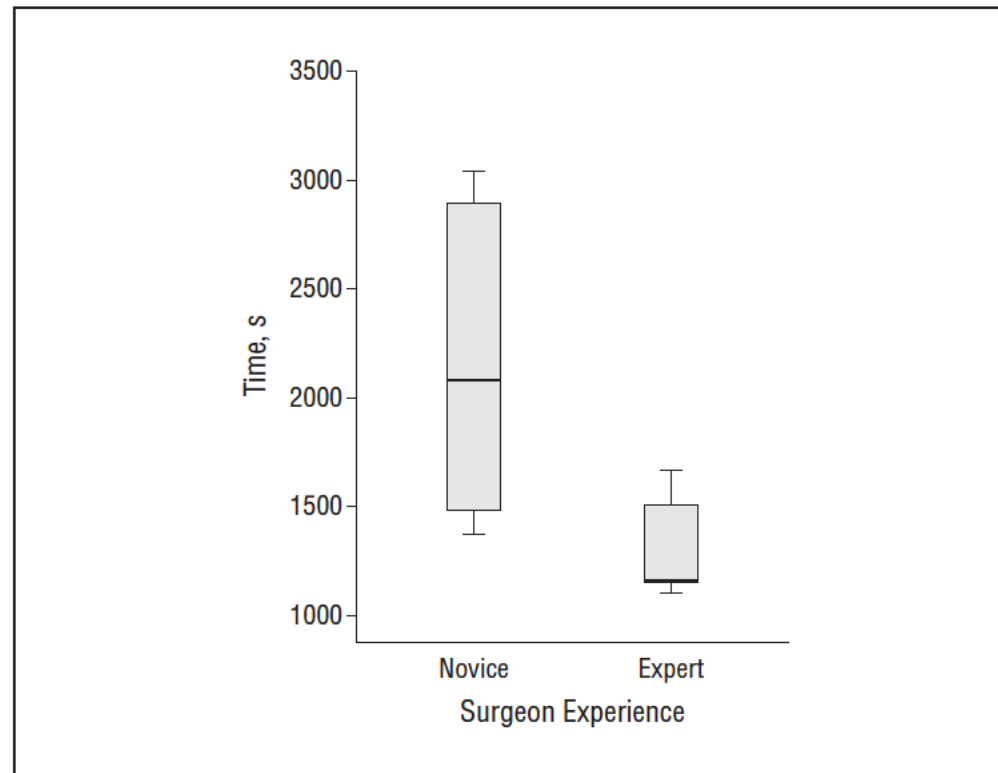
- SURF for feature descriptors such as corners, points
- Optical flow for motion tracking
- The application of point tracking in combination with motion analysis of such points enabled them to measure the instrument motion without the need for initialization.

# Results



The horizontal line within each box is the median value, and the top and bottom borders of the box are  $\pm 1$  SD with limit lines showing 95% CIs ( $\pm 2$  SDs). The plus signs beyond the whiskers are outliers.

# Results



# Results

- P value for approx t test between 2 groups were

| P value | Criteria        |
|---------|-----------------|
| 0.002   | Distance        |
| 0.05    | No of Movements |
| 0.004   | Time taken      |

# Advantages

- Directly track instruments and not surgeon hand motion
- Patterns similar to those previously established

# My comments

- Try hard to validate “To our knowledge, the present study is the first in which motion analysis was applied to actual videos of cataract surgery”.
- Each circumstance is unique. Repeatability is a question
- More of a documentation with very less engineering focus
- No discussion of experimental setup

# Relevance to my work

- Metrics for evaluating surgical skill
- Motivation for my work
- Better techniques for skill acquisition

Questions????