AIRTENTION

Pilot training assistane of the future

Pilot Training Assistance

Success Story of pilot training

Standardization of processes as **key success factor** for increasing Safety in aviation in the last half century

- **Automation** of activities
- **Enable correct decision-making under pressure**
- **Avoidance of errors**

Shortcomings of Pilot Training

Optimal results require **INDIVIDUALIZATION**

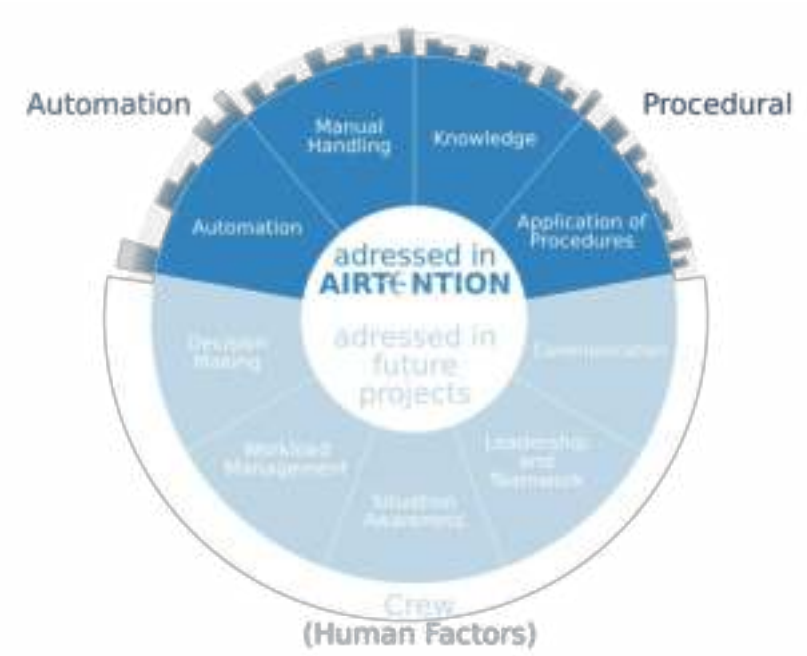
- **No objective measurements** of trainee performances
- **Subjective** evaluations and interpretations
- Limited availability of individual support
- No **perception-, attention-based training support**

Airtention Challenges

Focus on technical competencies

WHAT information?
WHEN is it relevant?
WHERE can it be obtained?

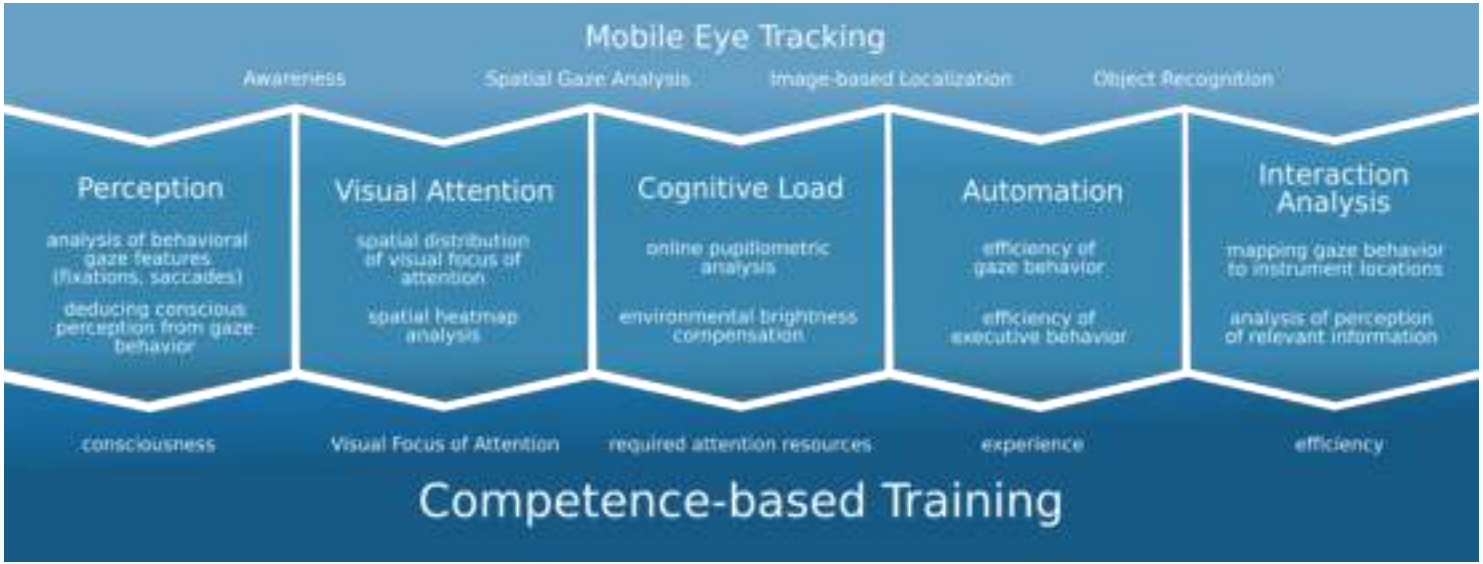
HOW EFFICIENT and AUTOMATED is the interaction / information intake?




VISUAL ATTENTION ANALYSIS
GAZE BEHAVIOR ANALYSIS
COGNITIVE LOAD ANALYSIS
PILOT TRAINING ASSISTANCE
INSTRUMENT INTERACTION ANALYSIS
PERCEPTION ANALYSIS
ATTENTION STRESS MGMT

SKILL & COMPETENCE APPROACH

Efficiency / Accuracy



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Technical Setup

TECHNICAL SETUP

Sensor Systems :: Pupil Invisible

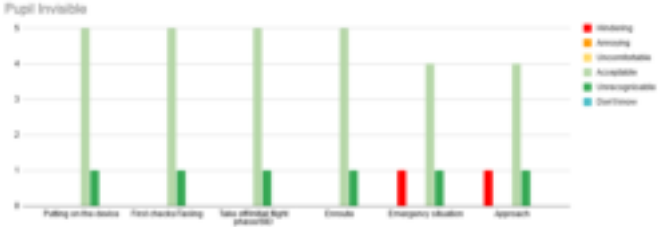
- „Just put it on and go:
  The world's first deep learning powered eye tracking glasses"
- Robust gaze estimation in any environment
- Robust to slippage on the wearing person
- Swappable lenses from -8 to +8 diopter

Pupil Invisible Eye Tracker

Pupil Invisible Eye Tracker

Technical Specifications

- 2 IR eye cameras with 200Hz @ 192x192px
- World camera with 30Hz @ 1088x1080px, 70°x70° FOV
- IMU with 200Hz included
- Microphone included
- Gaze data @ 55Hz

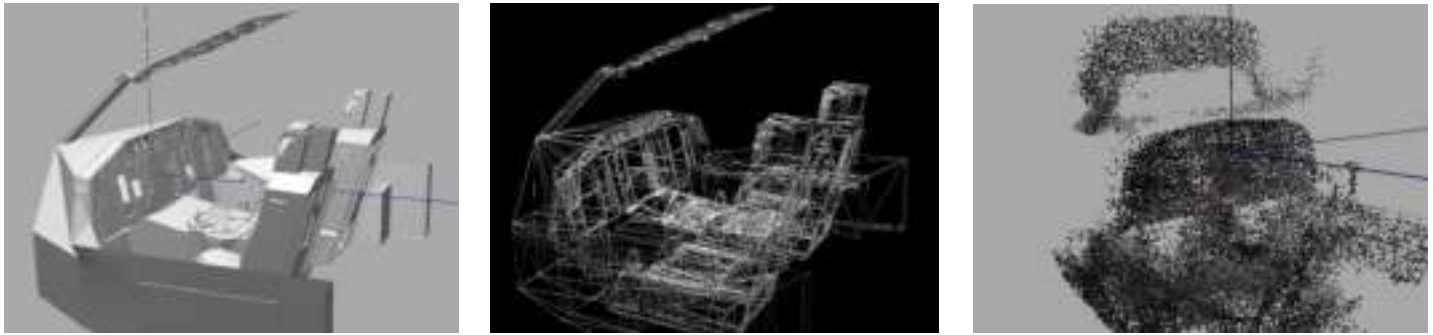


Obstrusiveness of student pilots in different phases of flight

TECHNICAL SETUP

Framework :: Environment Modeling

- modelling of cockpit environments for data visualization and analysis
- 1:1 virtual representation of the cockpit
- visualization styles: Mesh, Wireframe and Pointclouds



Attentive Cockpit Application‘s Mesh, Wireframe and Pointcloud View

Localization & Mapping

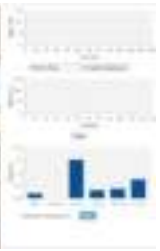
III: Absolute Localization (AL) + Relative Tracking (RT)

Localization results only used for visualization and not for instrument mapping or for interaction analysis

Absolute pose data in reference to 3D model

High rate pose data relative to point of system start up

Pose Tracking and Localization according to approach I or II



Object recognition and instrument mapping for interaction analysis

Requirements

- Stable, accurate and successful object recognition

Advantages

- Pose Tracking's accuracy requirements are lower

Disadvantages

- Drift compensation not possible
- Complex setup for visualization

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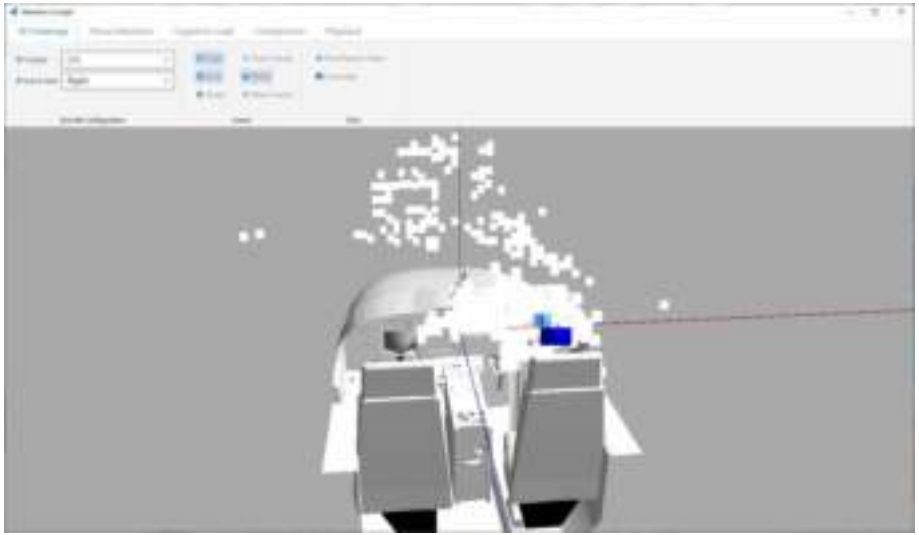
Modeling Pilot Performance

Modeling Pilot Performance

Analysis :: Heatmap Visual Attention



3D heatmap of visual attention after taxi and SID

3D heatmap of visual attention in approach

Modeling Pilot Performance

Conscious Perception

Analysis of behavior patterns for estimation of consciousness of interaction

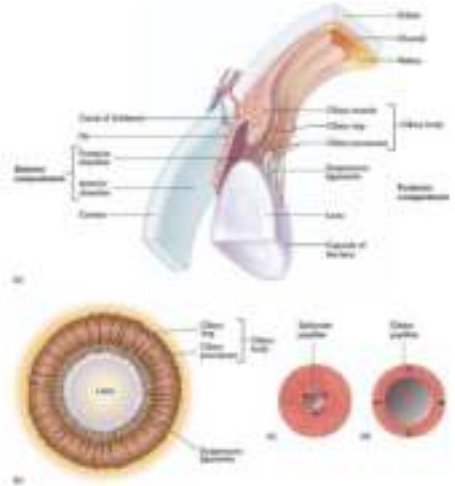
- **fixations, saccades, dwell time duration**, frequentation
- analysis of cognitive load
- Interpretation of gaze behavior in relation to **saliency of contextual stimuli** (covert (conscious behavior control) vs. overt behavior (extraneously trigger behavior control)
- **Smooth pursuit**

Modeling Pilot Performance

Cognitive Load from Pupil dilation

Established, reliable indicator for **cognitive activity / load**

- Pupil dilation shows correlations to para-sympathetical nervous system which is **associated with cognitive load**
- Spontaneous dilation **independent from illumination**
- Pupil Dilation changes associated with cognitive load: 0-1 mm
- Pupil Dilation changes associated with illumination: 0-6 mm



Physiology of the eye,
http://intranet.tdmu.edu.ua/data/kafedra/internal/normal_phiz/classes_stud/en/nurse/Bacchaour%20of%20sciences%20in%20nurses/ADN/17_Physiology_of_eye.htm

Problem:

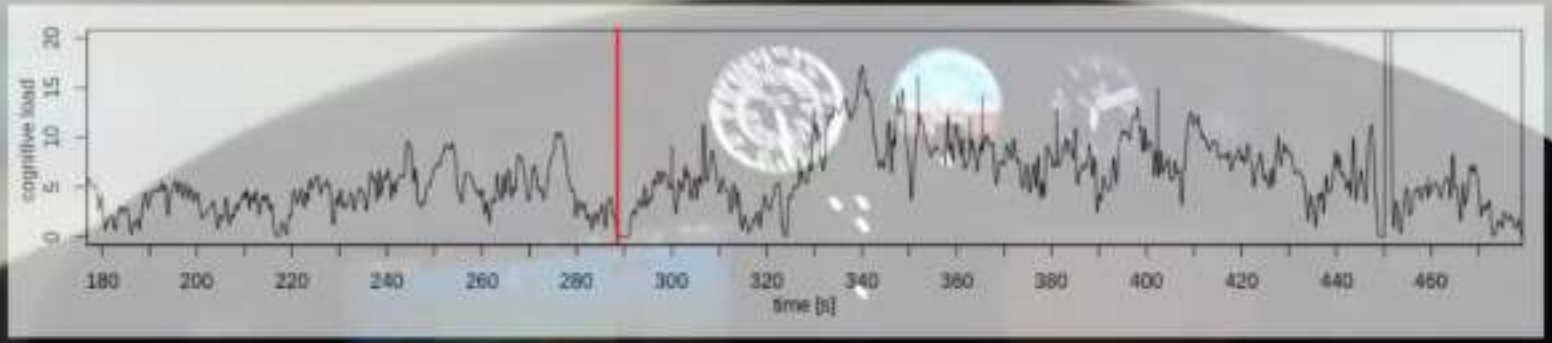
- **Separation** of cognitive effects **from light-induced effects** of pupil size

Gabay, Shai, Yoni Pertzov, and Avishai Henik. "Orienting of attention, pupil size, and the norepinephrine system." Attention, Perception, & Psychophysics 73.1 (2011): 123-129.

S. H. Fairclough and K. Houston. A metabolic measure of mental effort. Biological Psychology, 66(2):177–190, 2004.

Jepma, Marieke, and Sander Nieuwenhuis. "Pupil diameter predicts changes in the exploration–exploitation trade-off: evidence for the adaptive gain theory." Journal of cognitive neuroscience 23.7 (2011): 1587-1596.

Hoeks, Bert, and Willem JM Levelt. "Pupillary dilation as a measure of attention: A quantitative system analysis." Behavior Research Methods, Instruments, & Computers 25.1 (1993): 16-26



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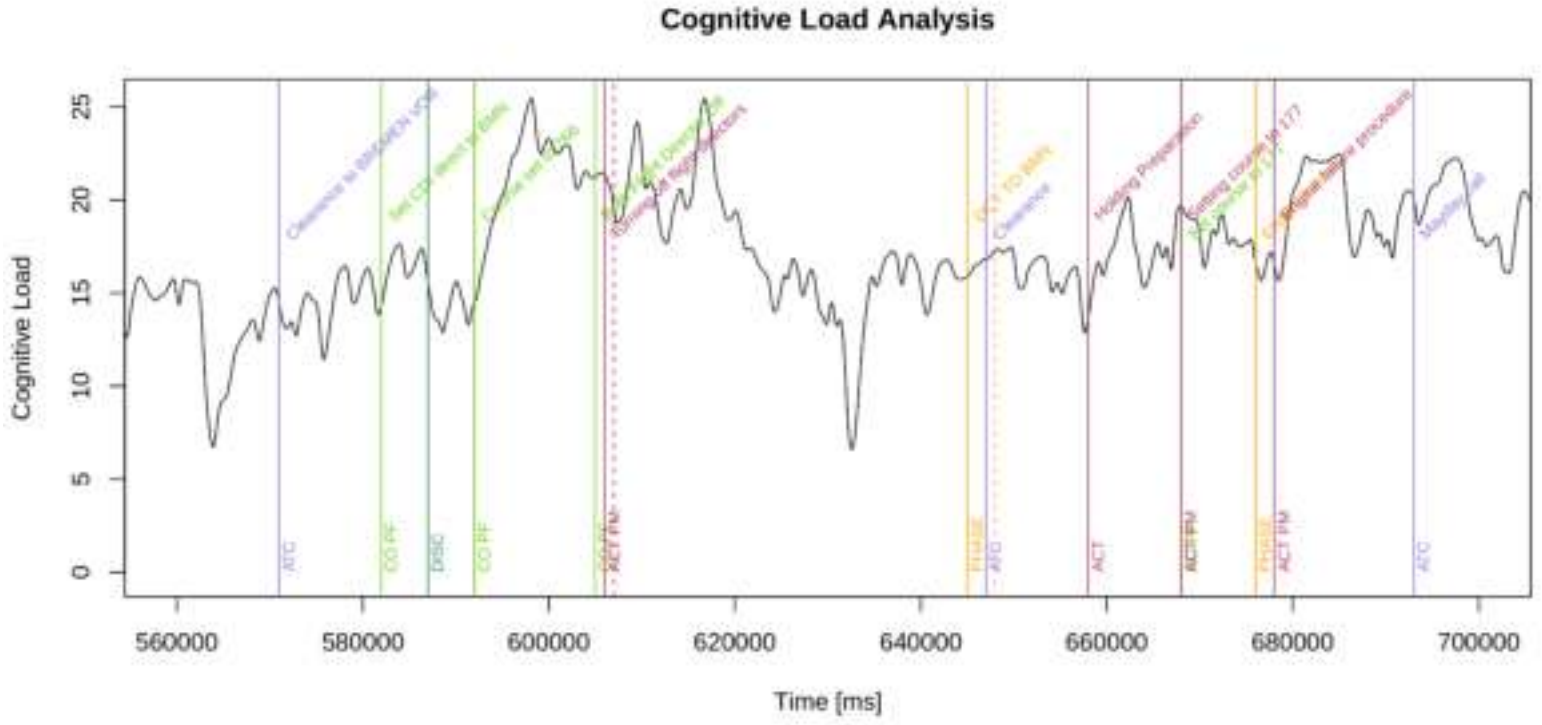
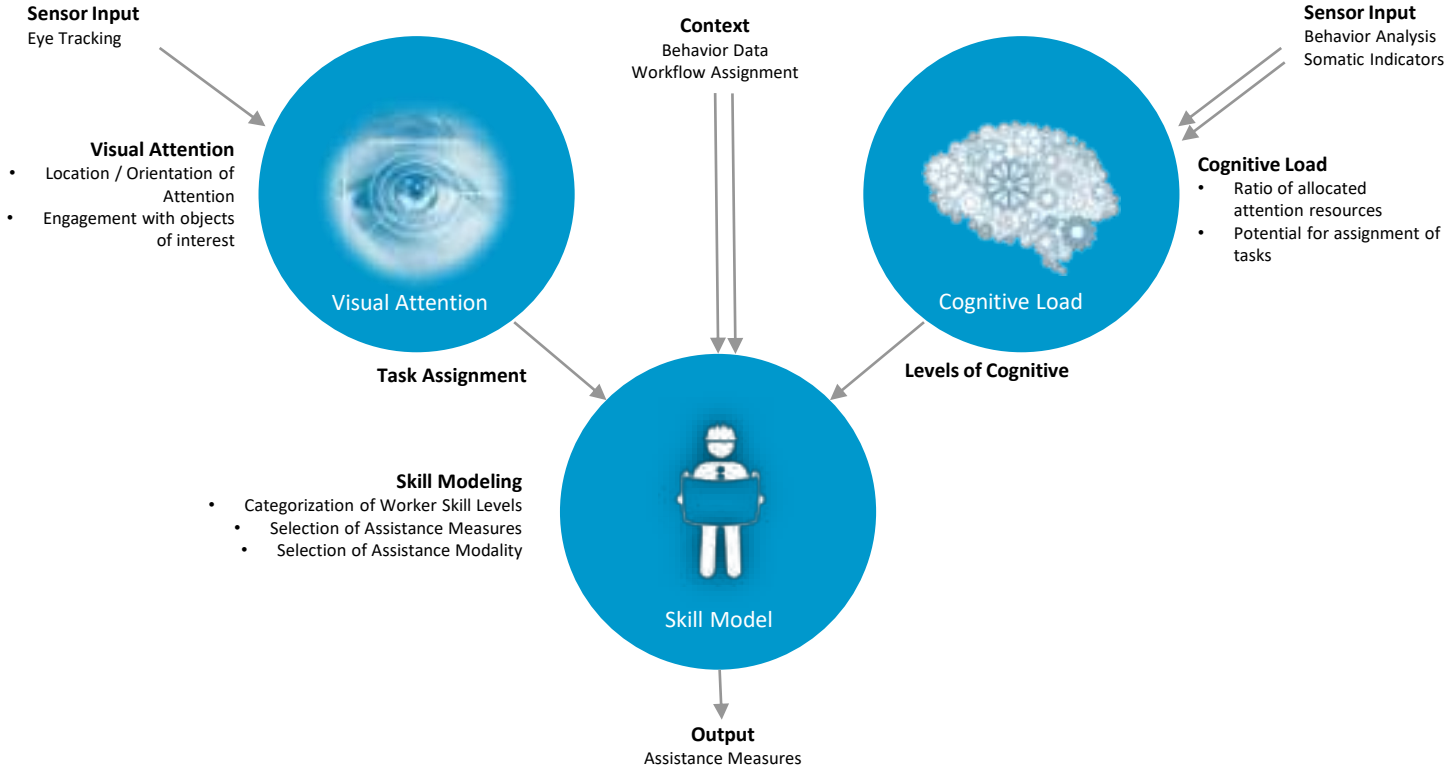
Modeling Pilot Performance

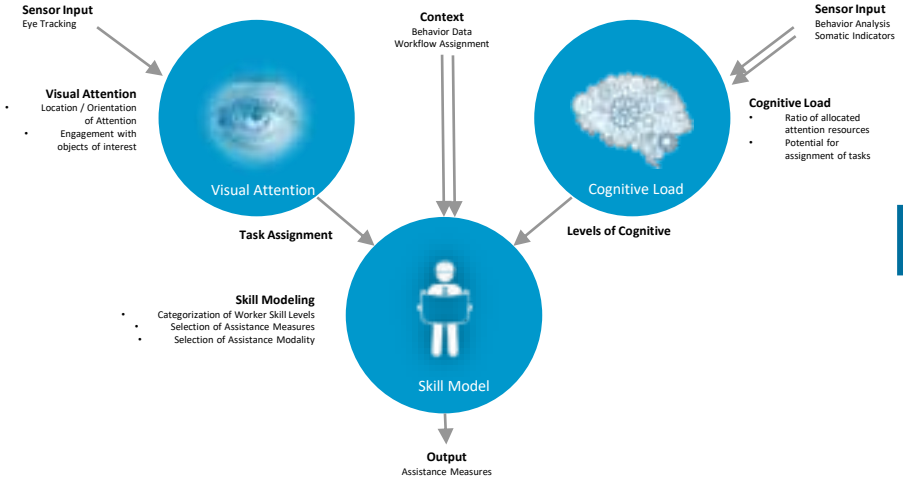


Modeling Pilot Performance



Modeling Pilot Performance

Mapping to CBT Models



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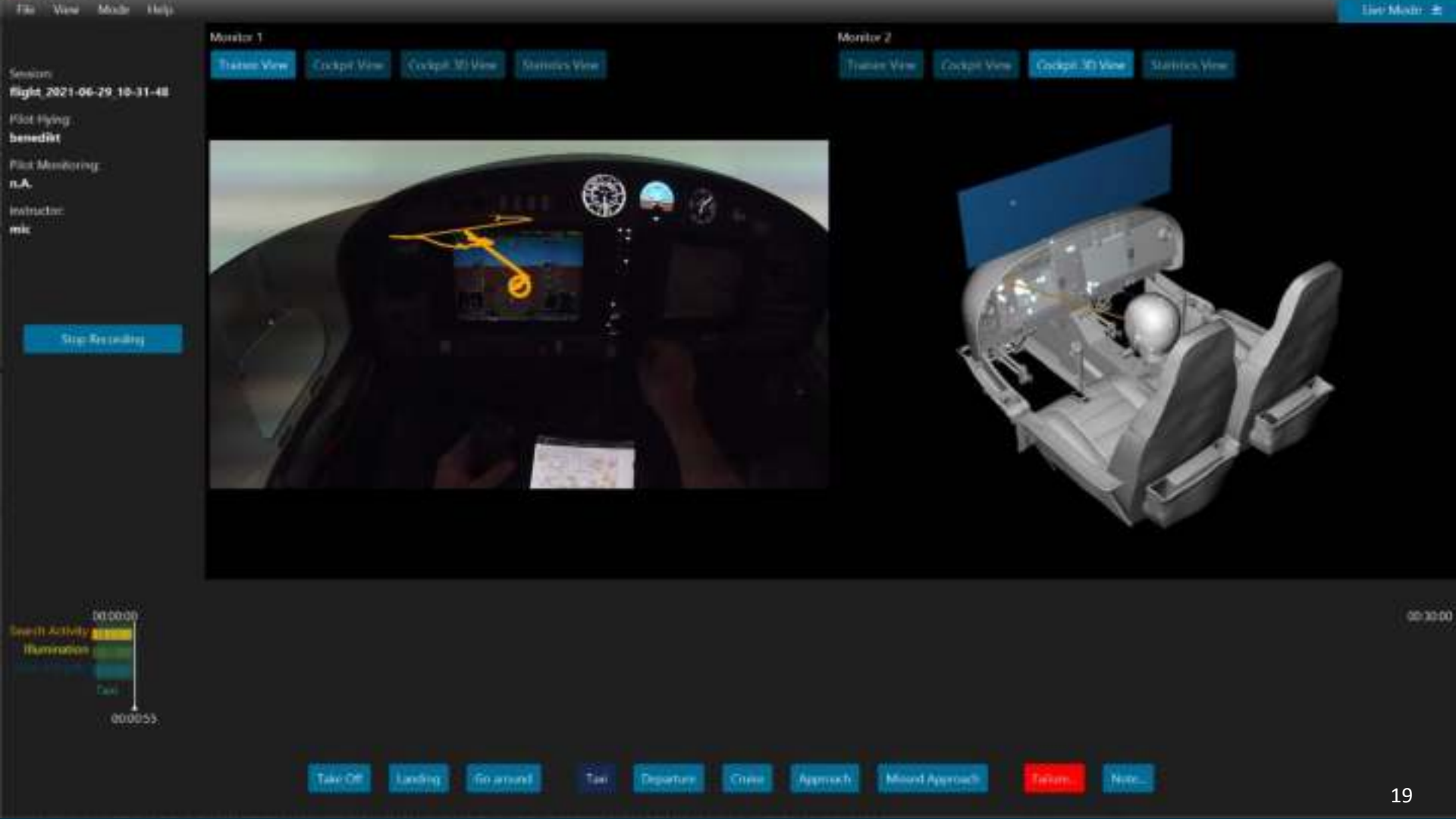
FlightAnalyzer Application


File
View
Mode
Help
Live Mode
Monitor 1
Trainee View
Cockpit View
Cockpit 3D View
Statistics View
Session:
flight_2021-06-29_10-31-48
Pilot Flying:
benedikt
Pilot Monitoring:
n.A.
Instructor:
mic
Stop Recording
Monitor 2
Trainee View
Cockpit View
Cockpit 3D View
Statistics View
00:00:00
Search Activity
Illumination
Take
00:00:55
00:30:00
Take Off
Landing
Go around
Taxi
Departure
Cruise
Approach
Missed Approach
Failure...
Note...


File View Mode Help
Live Mode
Session:
flight_2021-06-28_13-04-11
Pilot Flying:
benedikt
Pilot Monitoring:
n.a.
Instructor:
mic
Stop Recording
Monitor 1
Trainer View
Cockpit View
Cockpit 3D View
Statistics View
Monitor 2
Trainer View
Cockpit View
Cockpit 3D View
Statistics View
Gaze Distribution (since session start)
STBY AIRSPEED INDICATOR
STBY ALTIMETER
MFD
HSI
ARTIFICIAL HORIZON
STBY ARTIFICIAL HORIZON
ALTIMETER
Outside
STBY COMPASS
AIRSPEED INDICATOR
Fixation Duration (last 20 seconds)
300
250
00:00:00
00:30:00
Search Activity
Illumination
00:00:40
Take Off
Landing
Go around
Taxi
Departure
Cruise
Approach
Missed Approach
Failure
Note

File View Mode Help Dev

Debriefing Mode

Session
flight_2021-11-11_11-27-55

Pilot Flying
QPKJ4J

Pilot Monitoring
n.A.

Instructor
test

Pause Playback

Monitor 1

Trainee View | Cockpit View | Cockpit 3D View | Statistics View

Monitor 2

Trainee View | Cockpit View | Cockpit 3D View | Statistics View

00:00:00 01:47:17

Search Activity

Illumination

Departure | Cruise | Approach | Departure | Approach | Taxi

Take-off 00:00:59 | Landing | Go around | Landing

Events

Take-Off (T) | Landing (L) | Go around (G) | Failure... (F) | Procedure... (P) | Note... (N)

Flight Phase

Taxi (1) | Departure (2) | Cruise (3) | Approach (4) | Missed Approach (5)

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Validation

Validation :: Reference Data

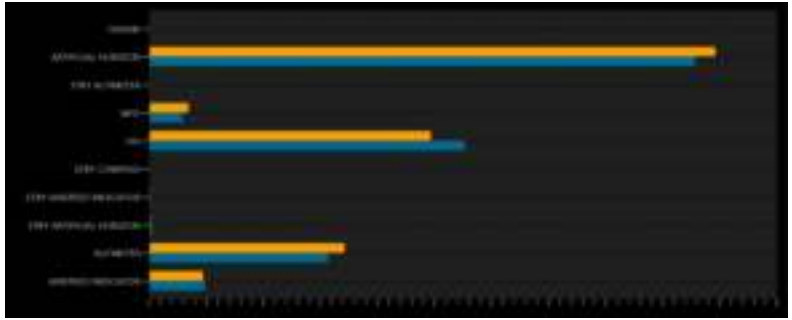
- Enable comparison of individual session data to references
- Flight phase dependent data (SID, Cruise, Approach)
- Sources for reference data:
  - Expert flights
    Gaze data of experienced pilots are used
  - Averaged data of multiple sessions
    Data for flight phases of multiple sessions are aggregated
- Data types:
  - Heatmap
  - Gaze distribution
  - Gaze AOI transitions
  - Advanced Metrics

Reference heatmap as averaged heatmap out of 15 ILS approaches

Validation :: Reference Data Comparison

Comparison to reference data as an approach to analyze source of performance shortages

Difference heatmap for approach: red shows “lacking areas”, yellow shows “additional areas” and black “matching areas”



Gaze distribution for approach: orange shows actual distribution, blue shows reference gaze distribution

Transition difference matrix: values show the percentual difference between transitions from one AOI to another

Transition metrics with reference values and difference to the reference value in blue

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Summary

USPs - current

- Combination of low-cost infrastructure / high quality interaction analysis (2k € vs. 25 – 80k€)
- Level of detail in visual interaction analysis
  - Continuous gaze tracking in 3D
  - High spatial resolution
- Cognitive load analysis
  - Qualitative / quantitative analysis
- Single system for live / debriefing assistance
- Without additional infrastructure
  - no alteration of certified simulators
  - Simple scalability

USPs - future



- Competence modeling for individuals and in comparison to colleagues
  - Visual features of cognition, perception, engagement, automation
- Adaptive training schedules
- Scalability towards real cockpits

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