MANIPULATING ATTENTION IN COMPUTER GAMES

LOW-LEVEL-BASED GUIDING PRINCIPLES

Gaze Prediction – Low level Saliency

In-game advertising

- **A FREQUENTLY SEARCHED GAME OBJECT IS MODIFIED TO SHARE PERCEPTUAL FEATURES WITH A TARGET ITEM. THE TARGET ITEM ATTRACTS ATTENTION**
- INCREASING THE SALIENCY OF ADVERTISING BILLBOARDS BY DESIGNING TASK-RELEVANT OBJECTS THAT ARE FREQUENTLY SEARCHED BY THE USER WITH COLORS AND OTHER PRINCIPAL PERCEPTUAL FEATURES (E.G. ORIENTATION) **THAT ARE COMMON WITH THE ADVERTISING BILLBOARDS**
- REQUIRES MANUAL 3D-MODEL MODIFICATIONS

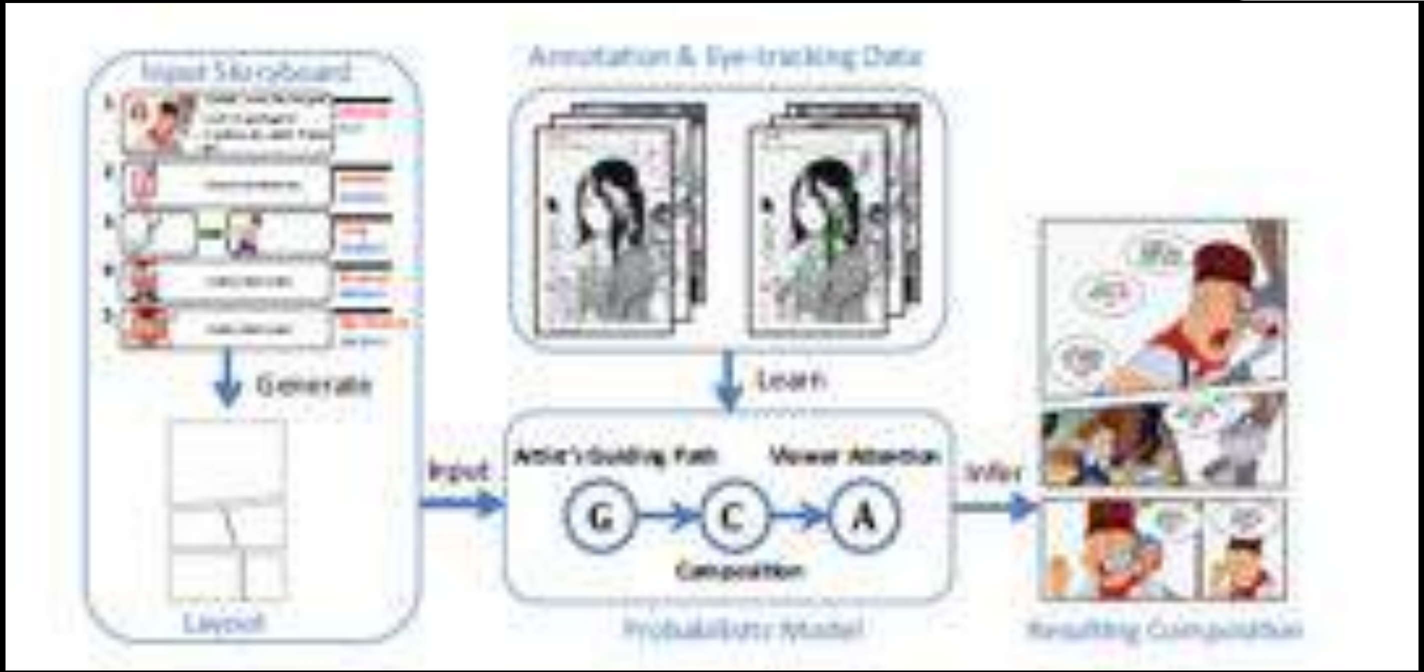
Memory task, task-relevant positioning and appearance

Bernhard et al. 2011

LOOK OVER HERE: ATTENTION-DIRECTING COMPOSITION OF MANGA ELEMENTS

Cao et al., 2014

Gaze Direction

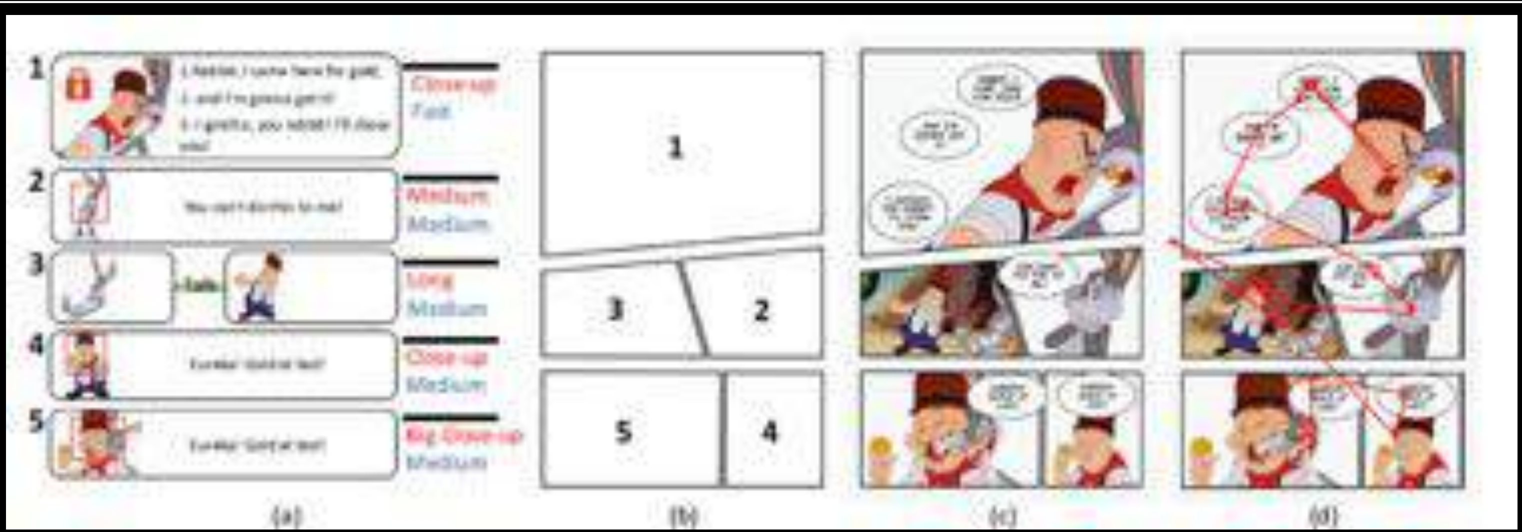


Manga training set, annotation main subjects/ballons and obtain gaze
A composition is synthesized interactively and the prob. model provides a set of composition suggestions

- **Manga Un elements are arranged in space rather than in time.** Consequently, communication of the story heavily relies on the reader attending to the right place at the right time
- For novices to synthesize a composition of panels **that can guide readers' attention interactively with user**
- **A probabilistic graphical model** that describes the relationships among the **artist's guiding path**, the **panel elements**, and the **viewer attention**, which can be effectively learned from existing manga pages and readers' gaze
- **The model enables interactive joint placement of subjects and balloons, producing effective storytelling compositions with respect to the user's given constraints.**

LOOK OVER HERE: ATTENTION-DIRECTING COMPOSITION OF MANGA ELEMENTS

Gaze Direction



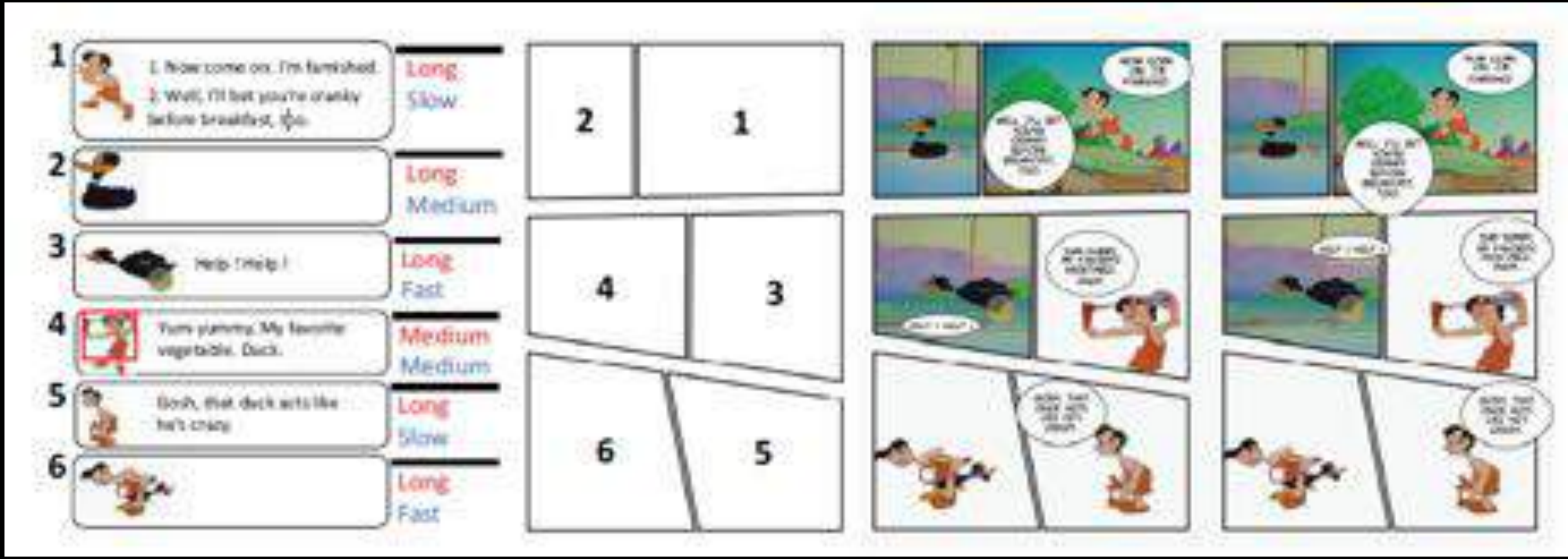
Shot type (red text), motion state (blue text), red rectangles ROIs

- THE TRAINING SET IS ANNOTATED (SUBJECTS/BALLONS) AND COLLECT READERS' EYE GAZE
- A COMPOSITION IS CREATED **INTERACTIVELY**, WHERE THE LEARNED PROBABILISTIC MODEL IS USED TO GENERATE A GALLERY OF COMPOSITION SUGGESTIONS, IN RESPONSE TO USER-PROVIDED HIGH-LEVEL SPECIFICATION
- THE USER GIVES **THE NUMBER OF PANELS THE SHOT TYPE AND MOTION STATE** (THE AMOUNT OF ACTION, E.G., SLOW, MEDIUM AND FAST) OF THE PANEL, AND ADD SUBJECTS ALONG WITH THEIR SCRIPTS
- GIVEN THE INPUT STORYBOARD, **A LAYOUT OF PANELS THAT BEST FITS THE INPUT ELEMENTS AND SEMANTICS** IS RETRIEVED, FROM A DATABASE OF LABELED LAYOUTS, AND THEN GENERATES COMPOSITION SUGGESTIONS

Cao et al., 2014

LOOK OVER HERE: ATTENTION-DIRECTING COMPOSITION OF MANGA ELEMENTS

Gaze Direction



Composition by their approach and heuristic method Third column balloons away

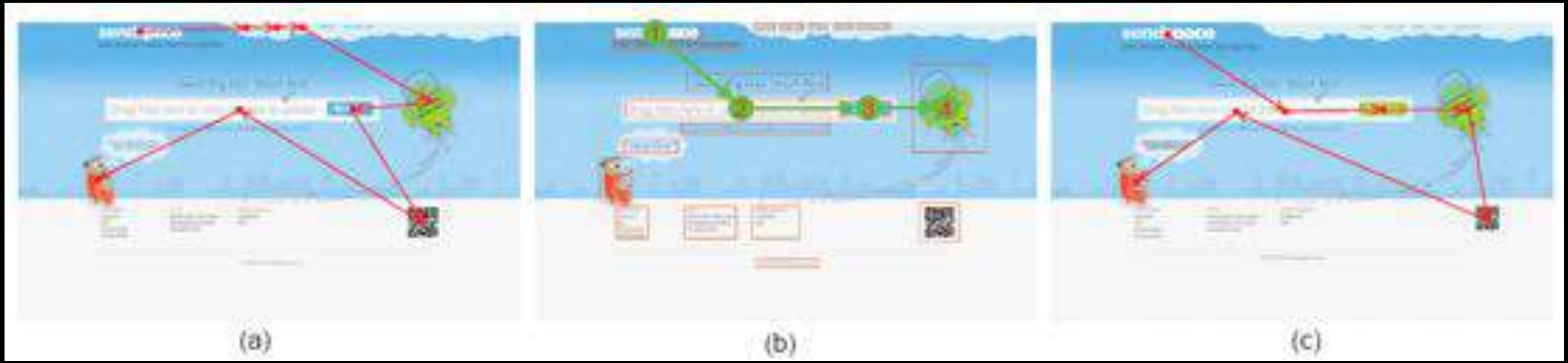
- MODEL COMPONENTS AND VARIABLES: **AGP, PANEL PROPERTIES** (SHOT TYPES, MOTION STATES), **LOCAL COMPOSITION MODEL** (SPATIAL DISTRIBUTION OF SUBJECTS WITHIN PANEL), **SUBJECT PLACEMENT** (COMBINATION BETWEEN LOCAL COMPOSITION IN THE PANEL AND GLOBAL WITHIN THE PAGE), **BALLOON PLACEMENT**, VIEWER ATTENTION TRANSITIONS WITHIN THE PANEL

Cao et al., 2014, ACM SIGGRAPH

DIRECTING USER ATTENTION VIA VISUAL FLOW ON WEB DESIGNS

Gaze Direction

a – input design
b – desired path
c – modified design, matching b



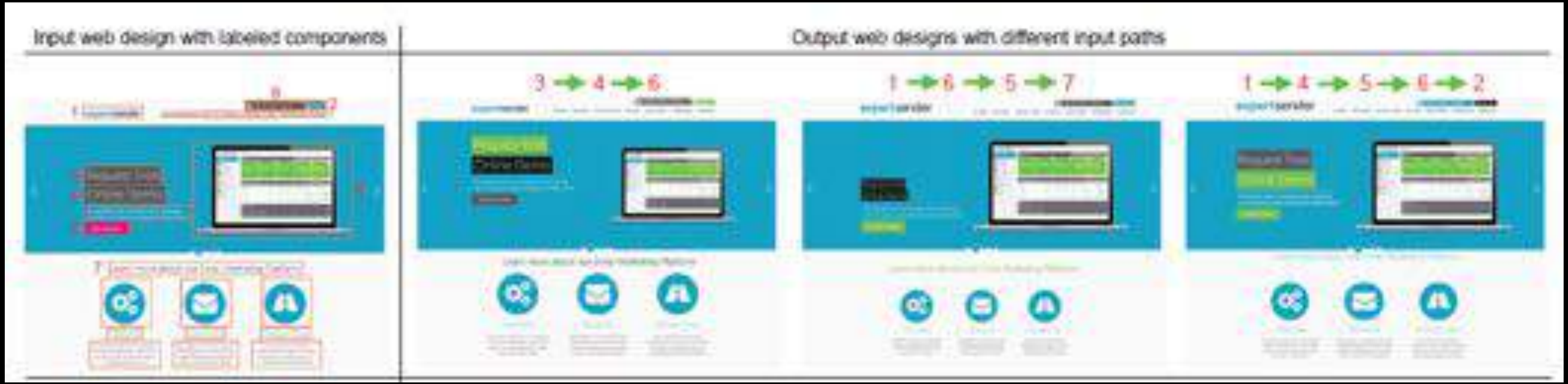
- WEB DESIGNERS TO EASILY DIRECT USER ATTENTION VIA VISUAL FLOW ON WEB DESIGNS
- BY COLLECTING USERS' EYE GAZE DATA ON REAL-WORLD WEB PAGES, TWO USER ATTENTION MODELS THAT CHARACTERIZE USER ATTENTION PATTERNS BETWEEN A PAIR OF PAGE COMPONENTS ARE BUILT
- **AN ATTENTION TRANSITION MODEL** PREDICTS THE LIKELIHOOD OF USER ATTENTION MOVING FROM ONE PAGE COMPONENT TO ANOTHER AND **AN ATTENTION ORDER MODEL** LIKELIHOOD ONE BEING VISITED BEFORE ANOTHER
- **THE TWO USER ATTENTION MODELS ARE USED IN AN OPTIMIZATION FRAMEWORK TO GENERATE REFINED WEB DESIGNS**

Pang et al., 2016, ACM SIGGRAPHASIA

DIRECTING USER ATTENTION VIA VISUAL FLOW ON WEB DESIGNS

Gaze Direction

To increase the prob. of eyes transiting from1 to 6, 3 and 4 are made smaller and text away from 1



- USER ATTENTION MODELS PRODUCE OPTIMIZED WEB DESIGNS BY ADJUSTING THE ATTRIBUTES OF THE PAGE COMPONENTS TO MINIMIZE AN OBJECTIVE FUNCTION **WITH ATTENTION, PRIOR, AND REGULARIZATION TERM**
- A DESIGNER SKETCHES A TRAJECTORY ACROSS TO INDICATE THE ATTENTION PATH THAT THEY EXPECT USERS TO FOLLOW. **THEN, THE WEB DESIGN IS OPTIMIZED AUTOMATICALLY TO MATCH DESIGNER'S INTENT**
- THE ATTENTION TERM ENCOURAGES USERS' ATTENTION **TO MATCH DESIGNERS' INTENDED VISUAL FLOW**. THE REGULARIZATION AND PRIOR TERMS IMPOSE **DESIGN PRINCIPLES WHILE KEEPING CLOSE TO ORIGINAL DESIGN**

Pang et al., 2016, ACM SIGGRAPHASIA

GAZE TRACKING

REAL-TIME CALIBRATION, LOW POWER TRACKING

A STATISTICAL APPROACH TO CONTINUOUS SELF CALIBRATING EYE GAZE TRACKING FOR VR

Gaze Tracking

Cameras sees eyes in mirror and IR reflecting mirror

LED illuminator display

- AUTOMATIC **EYE GAZE TRACKING** CONTINUOUSLY **UPDATING EYE TO SCREEN MAPPING** IN REAL-TIME
- NO CALIBRATION STEP NEEDED -- AUTOMATICALLY COMPENSATES FOR SMALL MOVEMENTS OF THE HEADSET /HEAD.
- **THE ALGORITHM FINDS CORRESPONDENCES BETWEEN CORNEAL AND SCREEN SPACE MOTION GENERATING GPRS**
- A COMBINATION OF THOSE MODELS PROVIDES A CONTINUOUS MAPPING FROM CORNEAL POSITION TO SCREEN SPACE POSITION. ACCURACY IS NEARLY AS GOOD AS ACHIEVED WITH AN EXPLICIT CALIBRATION STEP
- ALLOWING PEOPLE TO LOOK WHEREVER THEY WANT RATHER THAN REQUIRING THEM TO TRACK A SINGLE OBJECT

Tripathi & Guenter, 2016

A STATISTICAL APPROACH TO CONTINUOUS SELF CALIBRATING EYE GAZE TRACKING FOR VR

Gaze Tracking

IR illuminator creating glints

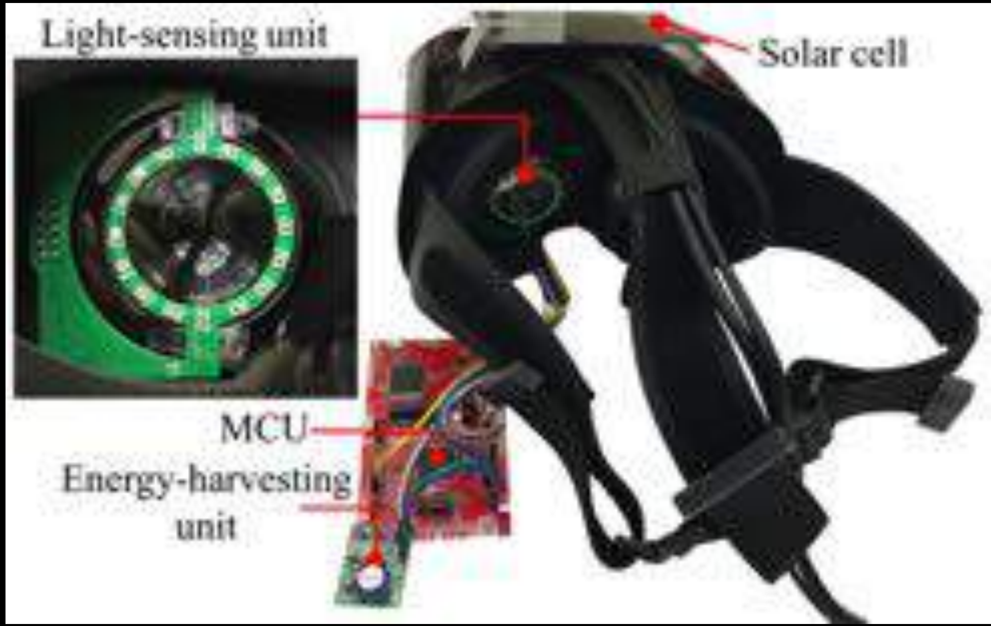
- An IR illuminator shines on the eye, **creating bright glints** on the surface of the cornea
- The x,y,z coordinates of the corneal center are the input to the learning algorithm
- Tracklet matching algorithm takes inputs of synchronized time series of **corneal locations** and the **coordinates of all objects on the screen space** and outputs **the single object whose trajectory is most similar to that of the eye** or nothing if no object is being followed.
- The process is continuously performed over small temporal windows

Tripathi & Guenter, 2016

UTLRA LOW POWER GAZE TRACKING FOR VIRTUAL REALITY

Gaze Tracking

- **REPLACING LOW POWER - COST CAMERAS WITH 16 LOW-COST ($2 EACH), SMALL PHOTODIODES**
- VR SCREEN LIGHT IS THE SOLE LIGHT SOURCE
- EACH **PHOTODIODE SENSES SCREEN LIGHT REFLECTED** BY USER'S EYEBALL IN A CERTAIN DIRECTION
- WHEN SCREEN LIGHT STRIKES THE PUPIL REGION, MOST LIGHT RAYS ARE ABSORBED WEAKENING THE REFLECTED LIGHT PERCEIVED BY PHOTODIODES IN THAT DIRECTION
- PUPIL MOVEMENT AFFECTS SPATIAL PATTERN OF CHANGES IN REFLECTED SCREEN LIGHT EXPLOITED TO INFER GAZE



LiGaze in Fove Photodiodes tracking gaze

Li et al., 2017, Sensys 2017

UTLRA LOW POWER GAZE TRACKING FOR VIRTUAL REALITY

Gaze Tracking

- **LIGAZE USES AN ADDITIONAL SET OF PHOTODIODES FACING THE DISPLAY TO SENSE INCOMING SCREEN LIGHT**
- BASED ON THE SENSED SCREEN LIGHT, LIGAZE ESTIMATES THE REFLECTED SCREEN LIGHT FROM PUPIL
- 3D GAZE VECTORS ARE INFERRED IN REAL TIME USING SUPERVISED LEARNING (TREE REGRESSION ALGORITHM)
- **USER DIVERSITY:** LIGAZE USES A QUICK CALIBRATION TO CUSTOMIZE THE REFLECTED LIGHT MODEL
- **LIGAZE DETECTS THE BLINK EVENT** BY EXAMINING PHOTODIODE DATA OVER TIME

(a) A ring-shaped PCB on a VR lens (b) Reflected light w/ center pupil

8 photodiodes per lens, light intensity at each photodiode

Li et al., 2017, Sensys 2017

UTLRA LOW POWER GAZE TRACKING FOR VIRTUAL REALITY

Gaze Tracking

- ESTIMATING THE REFLECTED SCREEN LIGHT EACH BACK PHOTODIODE PERCEIVES **IF PUPIL IS IN THE CENTER.** THE DIFFERENCE BETWEEN THIS ESTIMATE AND THE MEASURED REFLECTED LIGHT IS CAUSED BY THE OFFSET BETWEEN THE ACTUAL PUPIL POSITION AND THE CENTRE.

- **EVALUATION -- ACCURACY:** THE 3D ANGULAR DIFFERENCE BETWEEN 3D GAZE VECTORS INFERRED BY LIGAZE AND FOVE
- **PRECISION:** A MEASURE OF STABILITY OF GAZE INFERENCES
- **LATENCY:** THE DURATION THAT GAZE INFERENCE TAKES
- **OVERALL POWER CONSUMPTION**

(a) A ring-shaped PCB on a VR lens (b) Reflected light w/ center pupil

8 photodiodes per lens, light intensity at each photodiode

Li et al., 2017, Sensys 2017

STEREO GRADING

GAZE PREDICTION USING MACHINE LEARNING FOR GAMES

Dynamic Stereo Grading

Manipulating stereo content for comfortable viewing, a process called stereo grading
Player actions are highly correlated with the present state of a game (game variables)

1. **REAL-TIME GAZE PREDICTION BASED ON DECISION FORESTS WITHOUT MANUAL OBJECT TAGGING**
2. DYNAMIC, **COMFORTABLE** STEREO GRADING **WITHOUT CARDBOARDING EFFECTS**
3. ACCOUNT FOR TASK, LEARN FROM GAZE DATA

Koulieris et al. 2016

GAZE PREDICTION USING MACHINE LEARNING FOR GAMES

Dynamic Stereo Grading

A Machine Learning (ML) based predictor

- **IS AUTOMATIC** AVOIDING THE NEED FOR EMBEDDING CONTEXTUAL INFORMATION TO OBJECTS
- **YIELDS HIGH PREDICTION SUCCESS RATES, LEARNING** FROM GROUND TRUTH EYE TRACKING DATA
- **SUPPORTS OBJECT MOTION** IN CONTRAST TO PREVIOUS TASK-BASED AND HIGH LEVEL APPROACHES
- **CORRELATING VARIABLES OF THE GAME** WITH EYE TRACKING DATA, LEARNING ASSOCIATIONS BETWEEN THEM

ATTENTION MODEL
3-STEP PROCEDURE

Dynamic Stereo Grading

Identify important game variables and object classes

Data Collection

Classifier Training

Koulieris et al., 2016

ATTENTION MODEL
IDENTIFYING IMPORTANT VARIABLES

Dynamic Stereo Grading

FallenLog	Boat	WoodFence	Fence	Can
Ammo	Barrels	Brickhouse	Crate	Door
Rock	Tree	Water Pickable	Woodboard	Pond
Platform	Elevator	Robot	Soldier	Bush
Zombie	Mine	Food Pickable	Gun Pickable	

Automatically extracted class labels

- Employing a 3D model name parser that inferred abstract object classes or object categories used for training
- Focusing on the most informative variables **(13 from over 300)**, which varies significantly in time
- **Using eye-tracking to identify the correlation between the feature vector and the class labels (objects), based on the object class being attended given the current state of the game**

$Prop_{dx}$	$Robot_{dx}$	NPC_{dx}	Health	Ammo
$Prop_{dy}$	$Robot_{dy}$	NPC_{dy}	Hunger	
$Prop_{dz}$	$Robot_{dz}$	NPC_{dz}	Thirst	

The most informative variables that were selected for data collection. dx, dy, dz variables denote distances from the object.

ATTENTION MODEL

DF GENERATION AND TRAINING

Dynamic Stereo grading

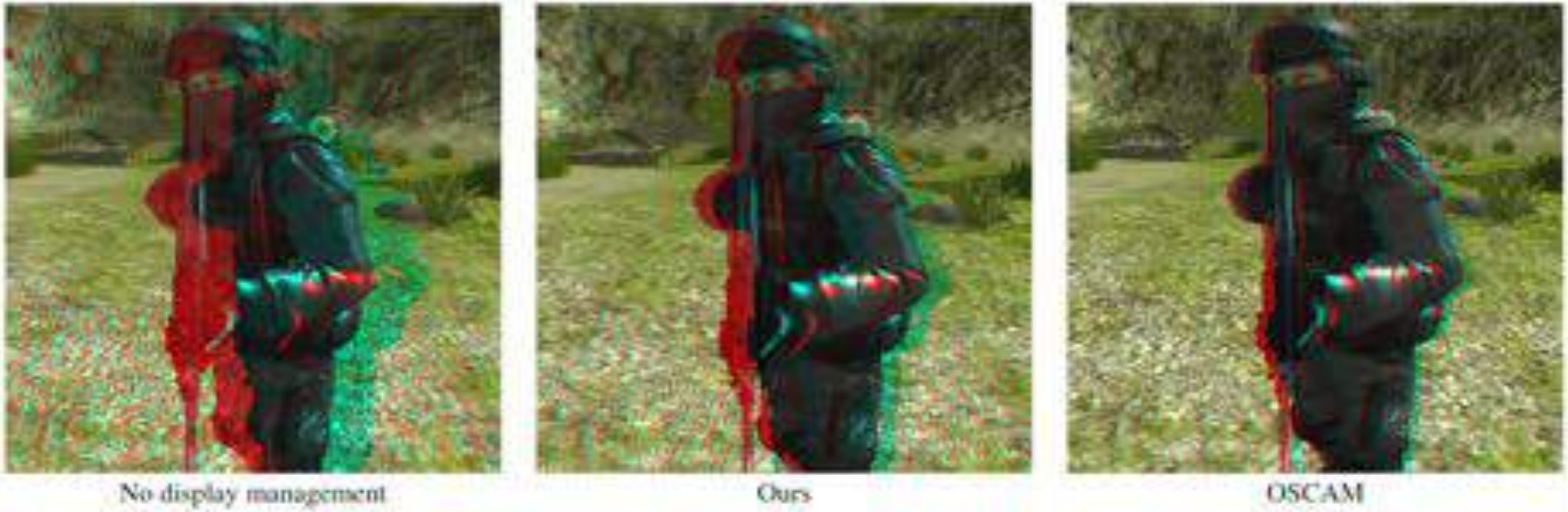
Training data in the database

- TRAINING DATA SET T, N SAMPLES OF M=13 FEATURES, T = (X1, Y1), (X2, Y2), …, (XN, YN)
- **EACH RECORD IN T INCLUDES AN INPUT FEATURE VECTOR**, XI = XI1, XI2, …, XIM **AND THE OBJECT CLASS LABEL** YI2 INDICATED BY THE EYE TRACKER AT THE SPECIFIC MOMENT THAT SAMPLE XI WAS TAKEN.
- 60-90 SECS GAMEPLAY, 20-MINUTE SESSIONS, REACH THE FLAMING SPACESHIP. AVOID ROBOTS, SOLDIERS, ZOMBIES, MINES
- **PLACE PREDICTED OBJECTS IN THE COMFORT ZONE**, CLOSE TO THE ZERO PARALLAX PLANE (VIRTUAL SCREEN)
- LINEARLY INTERPOLATE CAMERA SEPARATION AND ASYMMETRIC FRUSTUM PARAMETERS, AUTOMATIC

GAZE-BASED DYNAMIC STEREO GRADING

EXAMPLES

Dynamic Stereo Grading



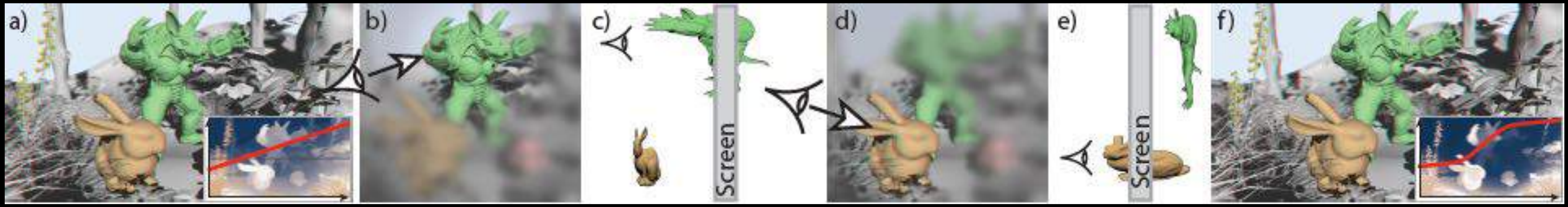
Left to right: No display management, Ours, OSCAM. Please use red/cyan anaglyph glasses; best viewed on a monitor.

Koulieris et al. 2016

GAZESTEREO3D: SEAMLESS DISPARITY MANIPULATIONS

Stereo depth adjustments

Modifying disparity of attended objects, seamless transition between them



Applying gradual depth adjustments at eye fixation, so that they remain unnoticeable

- **A REAL-TIME CONTROLLER THAT APPLIES LOCAL MANIPULATIONS TO STEREOSCOPIC CONTENT** TO FIND THE OPTIMUM BETWEEN DEPTH REPRODUCTION AND VISUAL COMFORT
- **IMPROVEMENTS IN DEPTH PERCEPTION WITHOUT SACRIFICING VISUAL QUALITY**
- TO ENHANCE PERCEIVED DEPTH THE METHOD **EXPANDS ITS RANGE AROUND THE FIXATION LOCATION** AND **REDUCES IT IN UNATTENDED REGIONS** THAT DO NOT CONTRIBUTE SIGNIFICANTLY TO DEPTH PERCEPTION
- **OBJECTS** AROUND THE FIXATION LOCATION **ARE MOVED TOWARDS THE SCREEN** TO REDUCE DISCOMFORT

Kellnhofer et al. 2016

GAZESTEREO3D: SEAMLESS DISPARITY MANIPULATIONS

Stereo depth adjustments

- **MEASURING THE HVS SENSITIVITY FOR THE MIN. SPEED OF A SCENE DEPTH RANGE** CHANGE AND **THE SPEED OF SMOOTHLY SHIFTING THE FIXATION POINT TOWARDS THE ACCOMMODATION (SCREEN) PLANE**
- CONTROLLING THE **SPEED** OF DEPTH MANIPULATIONS
- MEASURING THE JUST-NOTICEABLE SPEED OF DISPARITY CHANGES FOR DIFFERENT INITIAL DISPARITY VALUES
- **OFF-LINE APPLICATIONS, SUCH AS STEREOSCOPIC MOVIE PRODUCTION**, WHERE SKILLFUL DIRECTORS CAN RELIABLY GUIDE AND PREDICT VIEWERS' ATTENTION OR GET GAZE DATA IN PRE-VIEWING

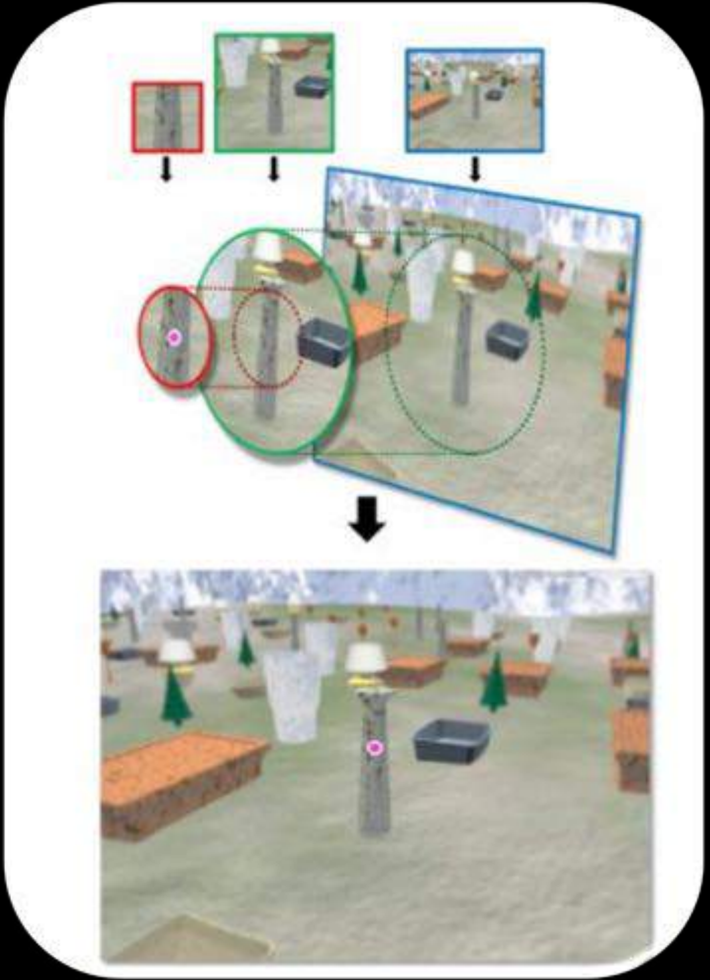
Kellnhofer etal., 2016

FOVEATED RENDERING

FOVEATED 3D GRAPHICS

Applications - Foveated Rendering

- METHOD **TRACKS THE USER'S GAZE POINT** AND RENDERS THREE IMAGE LAYERS AROUND IT AT PROGRESSIVELY HIGHER ANGULAR SIZE BUT
- **FOVEAL LAYER**
  - SMALLEST ANGULAR DIAMETER
  - RENDERS AT THE HIGHEST RESOLUTION AND LOD
  - USES THE FINEST LOD
- **MIDDLE & OUTER LAYERS**
  - COVER A PROGRESSIVELY LARGER ANGULAR DIAMETER
  - RENDER AT LOWER RESOLUTION AND LOWER LOD
  - UPDATED AT HALF THE TEMPORAL RATE OF THE FOVEAL LAYER
- **RESULT:** REDUCES PIXELS SHADED BY A FACTOR OF 10-15, RENDERING SPEED-UP BY A FACTOR OF 5, SEAMLESS IMAGE, MONITORING LATENCY, ANTIALIASING STRATEGY



Guenter et al. 2012

TOWARDS FOVEATED RENDERING FOR GAZE-TRACKED VIRTUAL REALITY

Applications - Foveated Rendering

1. **Starting with image** reducing peripheral detail via post process Gaussian blur
   Rendering the full scene in HD resolution -- Filtering the peripheral region
2. **As a result of filtering**, the peripheral region losses contrast. This creates the sense of tunnel vision to the users. **By applying post-process contrast enhancement users tolerate 2x larger blur radius, this is used as perceptual target**

- Result : 70% reduction of the pixels shaded on a display resolution of 2560 x 1440

Classroom scene (left), perceptually-validated target foveated image (right)

Patney et al. 2016

TOWARDS FOVEATED RENDERING FOR GAZE-TRACKED VIRTUAL REALITY

Applications - Foveated Rendering

- THE DESIGNED SYSTEM MATCHES **A PERCEPTUALLY VALIDATED TARGET** RATHER THAN OPTIMIZING FOR HIGHEST PERFORMANCE ON CURRENT HARDWARE.
- PERCEPTUAL TARGET (CONTRAST PRESERVING FILTERED IMAGE) **CLOSEST** TO NON-FOVEATED RESULTS
- **FOVEATED RENDERING APPROACHING PERCEPTUAL TARGET BY PRE-FILTERING SOME SHADING ATTRIBUTES WHILE UNDESAMPLING OTHERS**
- NORMALIZATION WITH A POST-PROCESS FOVEATED CONTRAST ENHANCEMENT FILTER
- POOR BLINK DETECTION IN THE GAZE TRACKER CAN INTRODUCE ARTIFACTS WHEN BLINKING, DUE TO

Desktop study with gaze tracker (left), HMD study embedded eye tracker (right)

Testing non-foveated, Guenter and coarse pixel shading

Patney et al. 2016

APPLICATIONS

Gaze driven video editing

GAZE DRIVEN VIDEO RE-EDITING

Jain et al. 2015

Applications – Video

(a) Original frame (1.75:1) (b) Scaling (1:1) (c) Cropping (1:1) (d) Letterboxing (1:1)

- AN ALGORITHM OPTIMIZING THE PATH OF A CROPPING WINDOW BASED ON THE COLLECTED EYE TRACKING DATA, **FINDS PLACES TO CUT, PAN AND ZOOM** AND COMPUTES THE SIZE OF THE CROPPING WINDOW
- **THE METHOD RE-EDITS VIDEO FOOTAGE -- AUTOMATIC PAN CUT AND ZOOM**
- **RATHER THAN GAZE PREDICTION, GAZE DATA ARE USED** TO REVEAL WHAT IS IMPORTANT TO NARRATIVE
- RANSAC OUTLIER DETECTION ON OBSERVED DATA

GAZE DRIVEN VIDEO RE-EDITING

Applications – Video

Re-edting widescreen video to smaller aspects via pans, cuts and zooms
Result in colour, original gray

- WHEN CUTS ARE REQUIRED TO PRODUCE A VIDEO WITH ADEQUATE COVERAGE OF THE EYETRACKING DATA, THE ALGORITHM FINDS **TWO PANNING PATHS AND AN OPTIMAL CUT BETWEEN THEM**
- THE SIZE OF THE CROPPING WINDOW IS DETERMINED **FROM THE SPREAD OF THE GAZE SAMPLES EVALUATION COMPARING VIEWERS' EYE TRACKING**

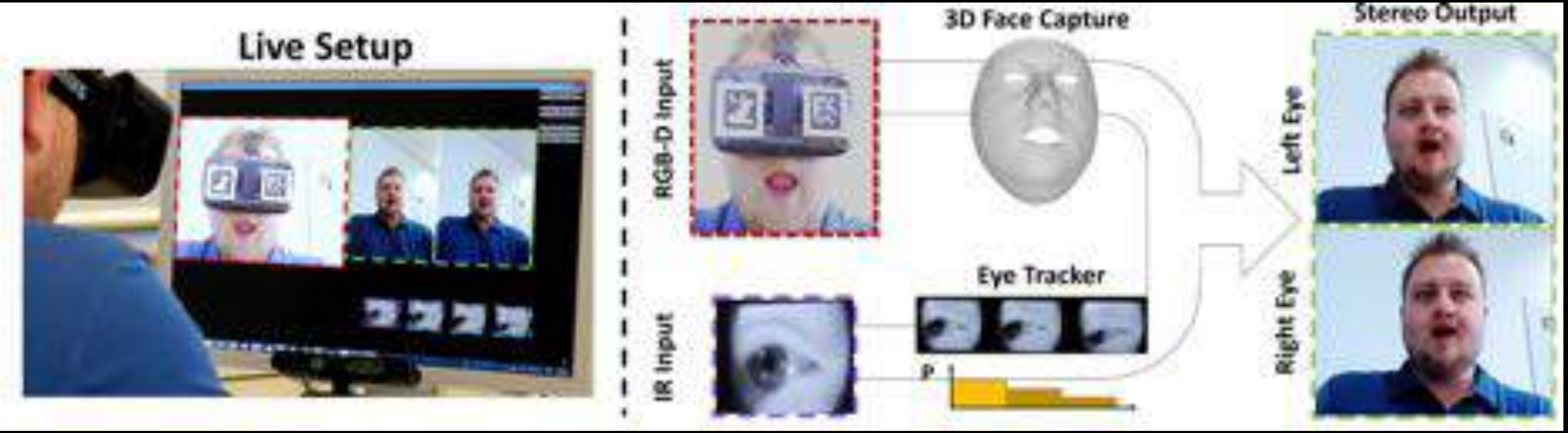
Jain et al.,

APPLICATIONS

FACEVR

FACEVR: REAL-TIME FACIAL REENACTMENT AND EYE GAZE CONTROL IN VIRTUAL REALITY

Applications – FACEVR



RGB-D camera, IR camera for eye gaze of one eye,
3D reconstructing face
'Removing' HMD

AR markers

- **FACEVR, A NEW REAL-TIME FACIAL REENACTMENT APPROACH** THAT CAN TRANSFER FACIAL EXPRESSIONS AND REALISTIC EYE APPEARANCE BETWEEN A SOURCE AND A TARGET ACTOR VIDEO
- IN ORDER TO CAPTURE A FACE, **A COMMODITY RGB-D SENSOR** WITH A FRONTAL VIEW; THE EYE REGION IS TRACKED USING A NEW DATA-DRIVEN APPROACH BASED ON DATA FROM **IR CAMERA** LOCATED IN THE HMD
- AR MARKERS IN FRONT OF HMD TO TRACK THE RIGID POSE OF HEAD
- ALLOWING ARTIFICIAL MODIFICATIONS OF FACE AND EYE

Thies et al. 2016

FACEVR: REAL-TIME FACIAL REENACTMENT AND EYE GAZE CONTROL IN VIRTUAL REALITY

Applications – FACEVR

- AN END-TO-END SYSTEM FOR FACIAL REENACTMENT FOR **VR TELECONFERENCING** REMOVING THE DISPLAY FROM EACH PARTICIPANT RENDERING THE UN-OCCLUDED VIEW AT THE OTHER END
- **THIS FACILITATES VR GOGGLE REMOVAL** FROM A VIDEO STREAM, ALLOWS FOR GAZE-AWARE VR CONVERSATIONS, AND ENABLES APPLICATIONS SUCH AS EYE-GAZE CORRECTION IN VIDEO CHATS

Thies et al., 2016

FACEVR: REAL-TIME FACIAL REENACTMENT AND EYE GAZE CONTROL IN VIRTUAL REALITY

Applications – FACEVR

Gaze correction for video conferencing, Gaze aware facial re-enactment modifying facial expressions and eye motion of target video and **Self-reenactment for VR video conferencing removing the HMD**

Thies et al., 2016

APPLICATIONS

Gaze-Driven Human Computer Interaction

BINOCULAR EYE TRACKING FOR THE CONTROL OF A 3D USER INTERFACE

Applications - Gaze-aware HCI

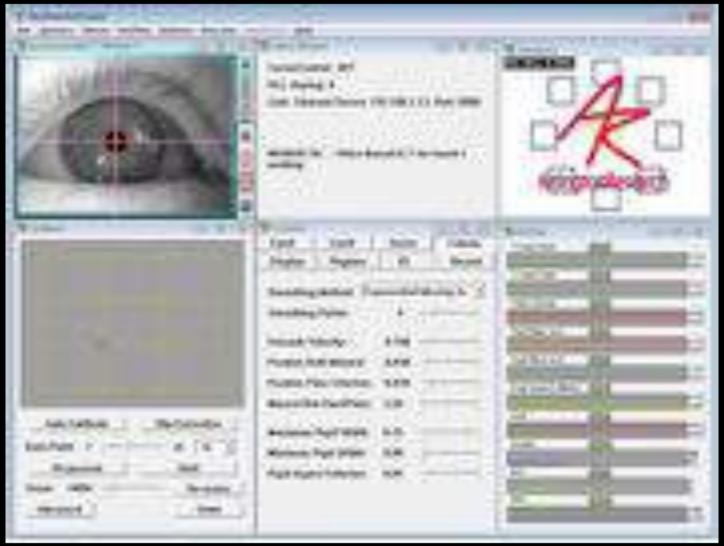
- **A 3D Multimedia User Interface based on eye-tracking**
- Six applications which cover commonly operated actions of computing such as mail composing and multimedia viewing
- Development of a system to handle eye tracking control/interactions
- Employ the gaze control approach to the custom-made MUI on a Head Mounted Display (HMD)
- Tasks are performed directly into the 3D spatial context without having to search for an out-of-view keyboard/mouse

Sidorakis et al., 2015

SOFTWARE ARCHITECTURE AND DEVELOPMENT FRAMEWORK

EYE TRACKING DEVICE'S SOFTWARE

Applications - Gaze-aware HCI



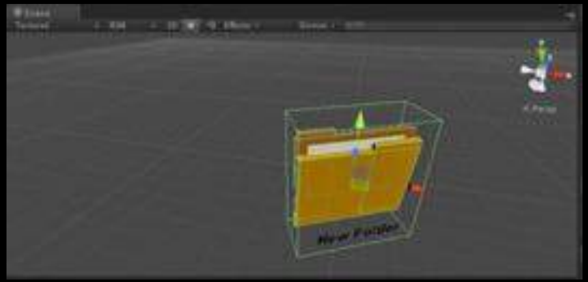
- EYE GAZE DATA COULD ALSO SIMULATE THE MOUSE CLICK BY DETECTING BLINKS
- **MIDAS' TOUCH & VIEWPOINT SETTINGS => FALSE BLINK DETECTION AND NON INTENDED INTERACTIONS**
- REPLACE WITH SINGLE BUTTON
  - SPACE KEY
- HEAD TRACKER DATA

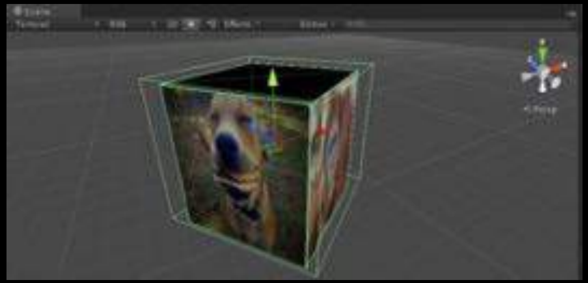
UI IMPLEMENTATION

CREATING THE VISUAL CONTENT – PICTURES EXPLORER

Applications - Gaze-aware HCI

- **Preview of windows photo directory**
- **The application searches through an image folder** and visualizes sub-folders and files on a virtual 3D slide-show supporting .JPG, .GIF, .TIFF, and .BMP formats
- Scene objects
  - Folder Model
  - File Model
  - Preview Slider Model
  - Back Button





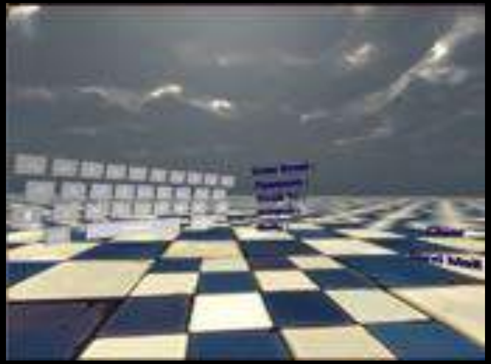
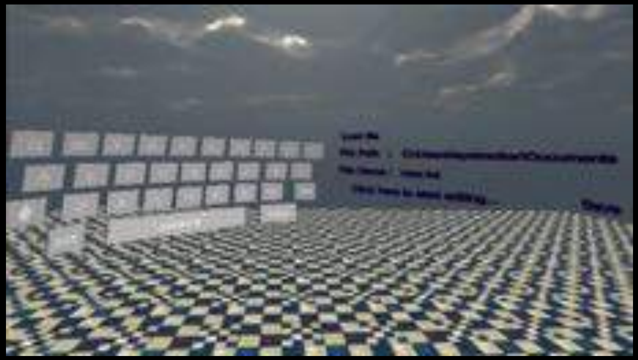
UI IMPLEMENTATION

CREATING THE VISUAL CONTENT – MUSIC PLAYER

Applications - Gaze-aware HCI

- **EMAIL COMPOSER**
  - USER FILLS HIS EMAIL AND PASSWORD, THE RECEIVER'S EMAIL, THE SUBJECT AND THE MAIN BODY OF THE MAIL
  - DEPICTS A 3D EMAIL FORM
- **TEXT PROCESSOR**
  - DEPICTS A 3D TEXT PROCESSOR
- **CUSTOM MADE 3D KEYBOARD**
  - 3 LAYOUTS (MOBILE TYPE)
  - CUSTOM KEYS
  - CUSTOM LETTER AND NUMBER TEXTURES



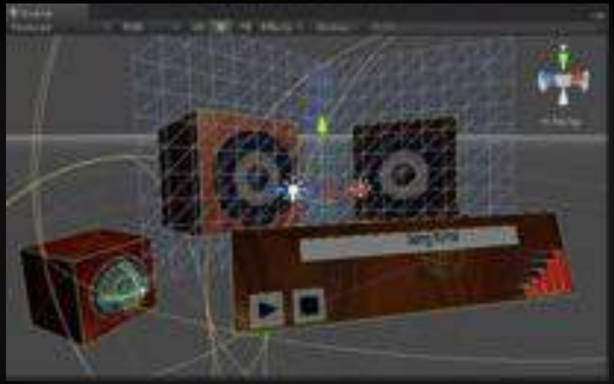




UI IMPLEMENTATION

CREATING THE VISUAL CONTENT – MUSIC PLAYER

Applications - Gaze-aware HCI

- **Explores music folder and exposes virtual 3D geometry for audio and playback control.**
- **4** Virtual speakers visualize the music and vibrate according to the music
- **Scene objects**
  - Song Files Model
  - Folder Model
  - Music Player Model
    - Play, Pause, Stop, Volume buttons



UI IMPLEMENTATION

CREATING THE VISUAL CONTENT – PUZZLE GAME

Applications - Gaze-aware HCI

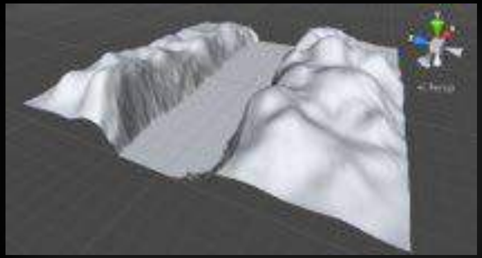
- **Puzzle game**
- A user-selected picture is fragmented in tiles randomized -- the user has to re-arrange the tiles to form the original picture and solve the puzzle
- **Picture Model**
  - Fragmented to 25 blocks
  - Textures offsets
- **Placeholder Model**

UI IMPLEMENTATION

CREATING THE VISUAL CONTENT – ACTION GAME (FLAPPY T.U.C)

Applications - Gaze-aware HCI

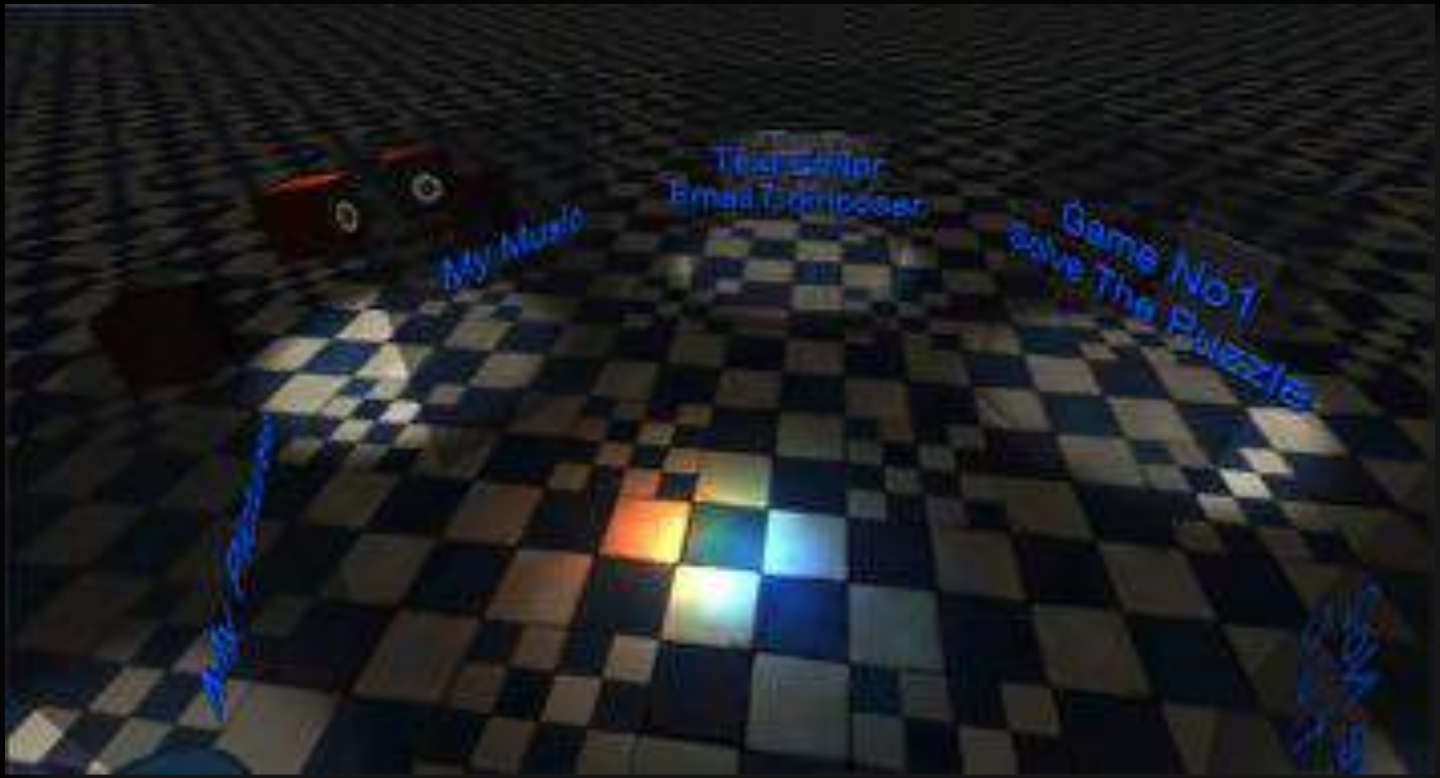
- **3D RENDITION OF THE CLASSIC FLAPPY BIRD GAME**
- OUTDOOR TERRAIN
- AIRPLANE MODEL (ASSET STORE)
- PIPES AND COINS
  - TEXTURES AND LIGHTS
- CABINS AND TREES (ASSET STORE)
- AUDIO SOURCES



UI Implementation

Setting up the virtual scene

- **Master Scene – Divided into six zones respectively**
- 3D MUI elements placed at static locations
  - Centered around a main pivot point
  - Observer interacts from various locations
- Lights – particle systems



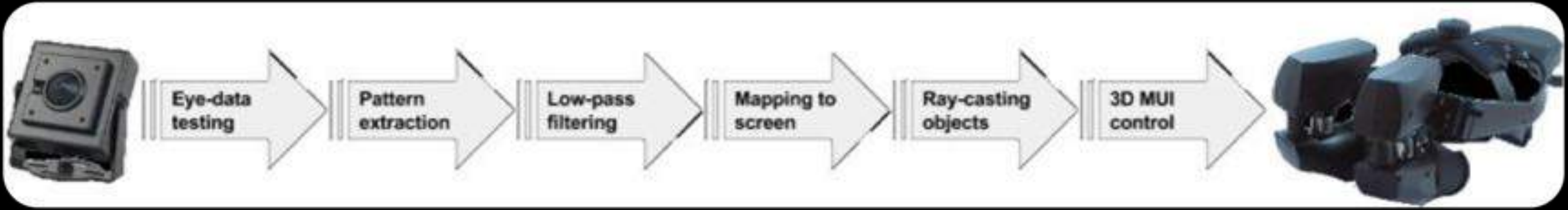
Sidorakis et al., 2015

Sidorakis et al., 2015

IMPLEMENTATION OF THE FRAMEWORK

COMMUNICATION WITH THE EYE AND HEAD TRACKING DEVICES

- **THE FIRST,** IS A RAW EYE DATA CALIBRATION COMPONENT PERFORMING CLEAR PUPIL AND GLINT TESTS, SIGNAL SMOOTHING AND FILTERING TO ELIMINATE NOISE
- **THE SECOND COMPONENT** IS AN EYE SCAN PATTERN EXTRACTION SYSTEM INDICATING THE DIRECTION OF THE EYE MOVEMENT, FIXATIONS AND BLINKS
- **THE THIRD,** IDENTIFIES THAT A CLEAR GLINT SIGNAL WAS LOCATED AND PERFORMS A LOW PASS FILTERING TO AVOID FLICKER
- **THE FOURTH COMPONENT** MAPS MOVEMENTS FROM EYE SPACE TO SCREEN COORDINATES
- **THE FIFTH PERFORMS** RAY-CASTING OVER THE 3D MENUS TO IDENTIFY FIXATED ITEMS
- **THE 3D MUI** RECEIVES DATA AND EXECUTES CONTROL ALGORITHMS FOR CURSOR MOTION MANIPULATION AND MENU ITEM HIGHLIGHTING



CONCLUSIONS

Gaze Aware Rendering and Displays

- **OVERALL LATENCY** OF THE RENDERING SYSTEM LEADS TO DISSATISFACTION
- **TACTILE MESH SALIENCY AND SALIENCY RELATED TO OTHER MODALITIES.** SALIENCY IN ROBOTICS, HOW A ROBOT ARM CAN GRASP AND/OR MANIPULATE AN OBJECT. UNDERSTANDING THE SALIENCY OF A VIRTUAL SHAPE CAN HELP TO UNDERSTAND ITS FUNCTIONALITY AS IF IT WERE A REAL OBJECT.

CONCLUSIONS

Gaze Aware Rendering and Displays

- **GAZE PREDICTION DEPTH ACQUISITION SEQUENTIAL MODELING WITH DEEP LEARNING MODELS** HAS BEEN GAINING EXTENSIVE RESEARCH LATELY, WHICH REACTIVATED THE INTEREST ON ATTENTION-BASED MODELS IN VARIOUS TASKS
- **HOW TO INCORPORATE HIGH LEVEL CUES INTO SALIENCY DETECTION**
- **DEALING WITH LARGE QUANTITIES OF EYE TRAKCING DATA:** AS EYETRACKING TECHNOLOGIES BECOME CHEAPER AND MORE EASILY AVAILABLE (FOR EXAMPLE, WEBCAM BASED EYETRACKING) IT WILL BECOME POSSIBLE TO OBTAIN EYETRACKING INFORMATION EVEN BY CROWDSOURCING VIEWERS

CONCLUSIONS

Gaze Aware Rendering and Displays

- **MORE COMFORTABLE STEREO VIEWING DEALING WITH THE** VERGENCE ACCOMMODATION CONFLICT
- **FOVEATED RENDERING:** INVESTIGATING WHAT CONSTITUTES ACCEPTABLE FOVEATION QUALITY WITHOUT ANY GROUND TRUTH REFERENT FOR DISPLAYS AT HIGHER RESOLUTION AND FIELD OF VIEW, AND TO INVESTIGATE HOW MUCH LATENCY IS TOLERABLE
- **ALTERNATIVE INPUT DEVICES** TO COMPUTER MOUSE ARE BECOMING A SUBJECT OF RESEARCH

THANK YOU

https://vrdisplays.github.io/ieeevr2018/