ETTAC 2020

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Judging qualification, gender, and age of the observer based on gaze patterns when looking at faces

The experiment

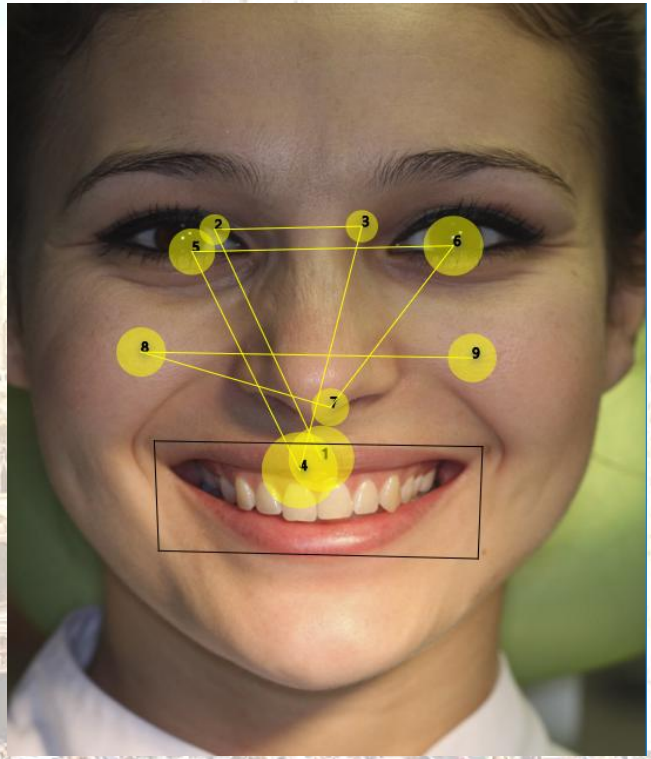
- Recording gaze signal of people looking at faces with subtle teeth imperfections
  - Both dental specialists and laymen
- Part of the bigger study (with Dentofacial Orthopedics specialists)
- Aim of this study: check if it possible to learn something about observers analysing their gaze patterns

Motivation

- Face observing patterns
  - very specific for humans
  - we can recognize others intentions or mood
  - may be used to diagnose autism or Alzheimer disease
  - specific for individuals (idiosyncratic)
  - different for races and age
  - depend on the familiarity of the face being observed

Gaze pattern for face observation

- Typical pattern:
  - start with eyes
  - look between nose and mouth
- Eyes-Mouth triangle
- The differences:
  - fixation durations on different face parts



The purpose of the research

- Check if gaze pattern reveals:
  - gender of the observer
  - qualification of the observer (layman, dentists)
  - age of the observer
  - gender of the person on the image
- The analyzes done separately for laymen and specialists

Material

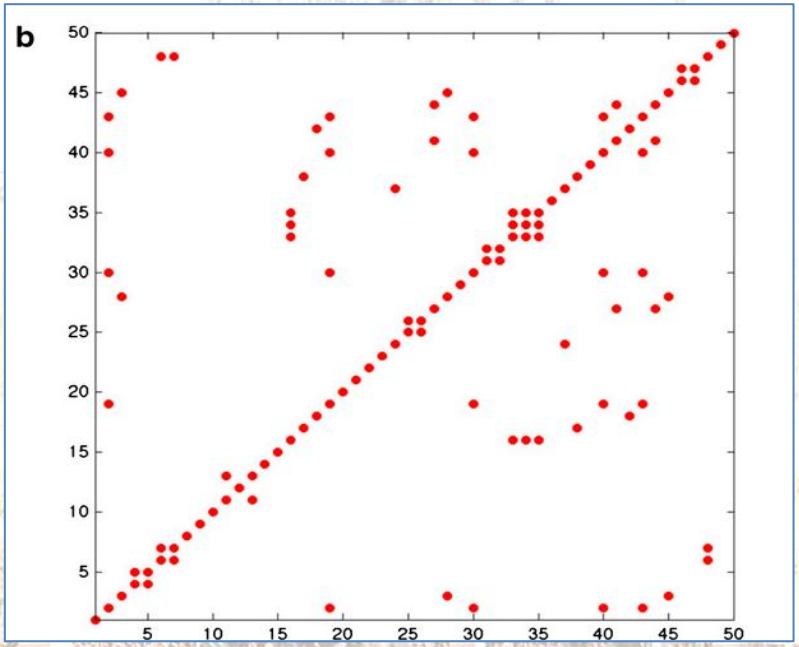
- 48 human faces images
  - every image (face) was presented for 6 seconds
- 53 observers: 25 nonspecialists, 28 dental specialists
- 60 Hz sampling rate – 360 gaze points per observation
- After removing the noisy data, 1883 observations:
  - 929 observations of specialists, 954 of laymen
  - 654 women, 1229 men
  - 1188 female faces, 695 male faces

Methods

- General metrics: fixNum, fixAvgDur, sacAvgLen, sacLen
- AOI metrics: mouthTimeTo, mouthTime, incisorsTimeTo, incisorsTime
- Reccurence Plot (RP) metrics: recurrence, determination, laminarity, center of recurrence mass
- Gaze Self-Similarity Plot (GSSP) metrics: contrast, homogeneity, uniformity
- Coverage metrics: coverage 5x5, ,7x7, 10x10

Recurrence plot

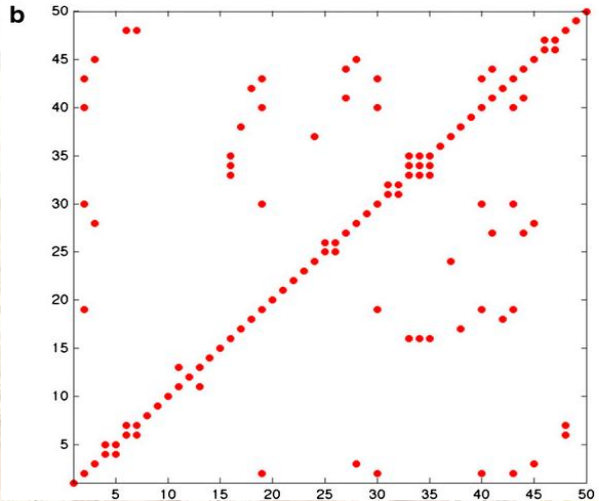
- Matrix N x N where N is number of fixations
- For every point
  - p(i, j) = 1 if dist(f_j, f_i) < threshold
  - p(i, j) = 0 otherwise



[Anderson et al 2013]

Recurrence plot

- Recurrence – number of dots
- Determinism – number of diagonal lines
  - Repeating sequences of fixations
- Laminarity – number of vertical and horizontal lines
  - When gaze returns to the previous locaction
- Center of recurrence mass (CORM)
  - Distance of dots to diagonal

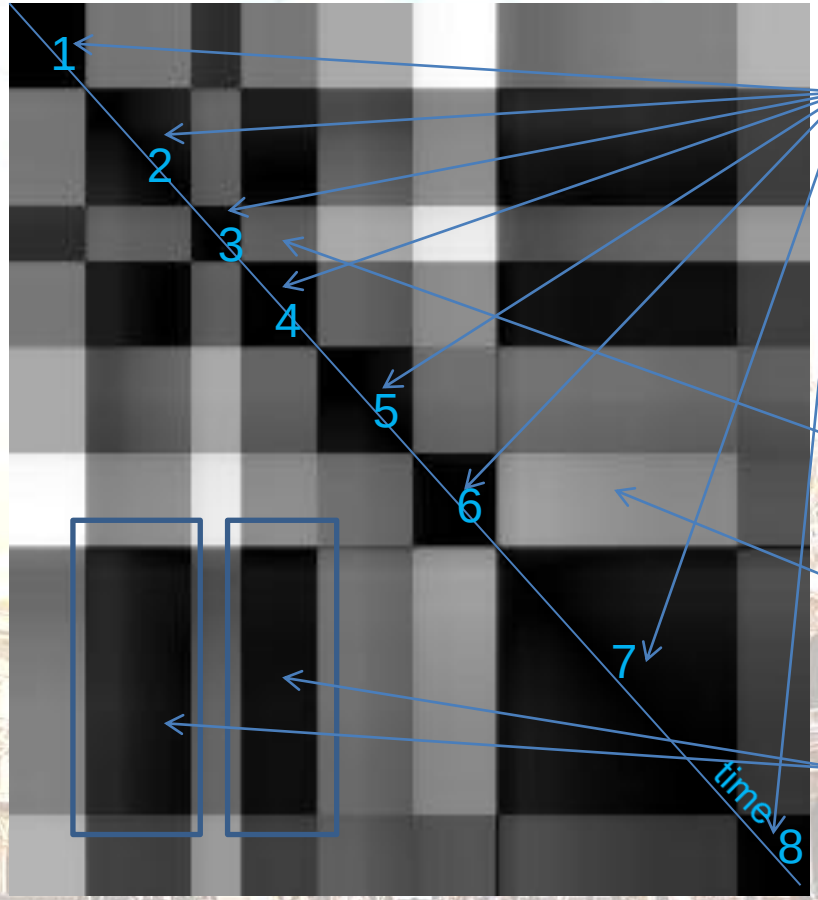


[Anderson et al 2013]

Gaze Self-Similarity Plot (GSSP)

- Input: sequence of N gazes
- Output: matrix of N x N pixels
- For every pixel
  - $p(i, j) = dist(g_i, g_j)$

[Kasprowski et al 2017]



Gaze Self-Similarity Plots

Measures (based on co-ocurrence ma

- Homogeneity
  - to what extend nearby gazes are in sim
- Contrast
  - sensitive to long jumps fr
- Uniformity
  - measures gaze sequences r
    It is high when the GSSP co

[Kasprowski et al 2017]

$$cm^{H}_{dx,dy}(a,b) = \sum_{x=1}^{n}\sum_{y=x+1}^{n}\begin{cases}1, & \begin{matrix}I(x,y)=a\\ and\\ I(x+dx,y+dy)=b\end{matrix}\\ 0, & otherwise\end{cases} \quad (10)$$

$$cm^{V}_{dx,dy}(a,b) = \sum_{y=1}^{n}\sum_{x=y+1}^{n}\begin{cases}1, & \begin{matrix}I(x,y)=a\\ and\\ I(x+dx,y+dy)=b\end{matrix}\\ 0, & otherwise\end{cases} \quad (11)$$

Homogeneity. The homogeneity of an image gives information to what extend nearby gazes are in similar locations.

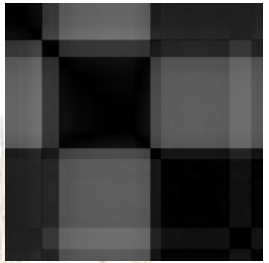
$$homogeneity_{dx,dy} = \sum_{i=1}^{n}\sum_{j=1}^{n}\frac{cm_{dx,dy}(i,j)}{1+|i-j|} \quad (12)$$

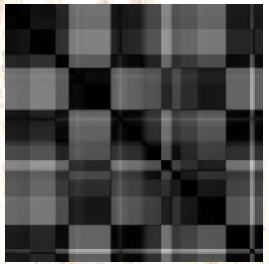
Contrast. The contrast is sensitive to long jumps from one gaze point to another.

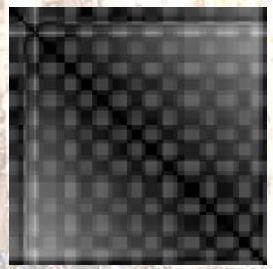
$$contrast_{dx,dy} = \sum_{i=1}^{n}\sum_{j=1}^{n}(i-j)^2 cm_{dx,dy}(i,j) \quad (13)$$

Uniformity. Uniformity (also called energy) measures gaze pairs repetitions. It is high when the GSSP contains similar areas.

$$uniformity_{dx,dy} = \sum_{i=1}^{n}\sum_{j=1}^{n}(cm_{dx,dy}(i,j))^2 \quad (14)$$







Statistical tests

- Four independent variables:
  - Qualification
  - Gender (separately for specialists and laymen)
  - Age of the observer
  - Gender of the face in the image
- t-Student or ANOVA tests to check significant differences for dependent variables (RP, GSSP)

Results

- Significant differences for qualification for: contrast and homogeneity
- Significant differences for gender for uniformity
- Significant differences for age groups
- No significant differences for gender of the face

Uniformity vs. Contrast

Table 2. Features values - differences for laypeople and specialists.

feature	laymen	specialists	t(1883)	p-value	
fixNum	14,6	15,4	-3,289	0,001	**
fixAvgDur	345,9	359,4	-0,704	0,482	
sacAvgLen	6,9	4,7	20,024	0	***
sacLen	100,2	70,6	14,976	0	***
mouthTimeto	2253,2	1054	14,12	0	***
mouthTime	986	1977,4	-14,818	0	***
incisTimeto	3991,3	2574,8	13,573	0	***
incistime	428,5	962,7	-10,353	0	***
rec	13,1	21,3	-12,178	0	***
det	30,8	46,1	-9,167	0	***
lam	51,6	80,4	-14,702	0	***
corm	4,8	8,1	-8,822	0	***
coverage5	0,21	0,17	13,204	0	***
coverage7	0,14	0,11	11,043	0	***
coverage10	0,08	0,07	10,17	0	***
contrast	102,4	186,6	7,23	0	***
homog	332,3	290,6	13,25	0	***
uniformity	202,4	220,3	-2,18	0,03	*

Table 3. Gender differences for non-specialists.

feature	female	male	t(954)	p-value	
fixNum	12,9	15,6	-10,36	0	***
fixAvgLen	422,7	297,5	9,85	0	***
sacAvgLen	7,4	6,6	4,32	0	***
sacLen	95,5	103,2	-2,62	0,01	**
mouthTimeTo	2051,8	2380,2	-2,35	0,02	*
mouthTime	1409,1	719,2	8,31	0	***
incisTimeTo	4076	3937,9	0,93	0,35	
incisTime	587,1	328,4	4,35	0	***
rec	13,4	13	0,57	0,57	
det	27,9	32,7	-2,17	0,03	*
lam	39	59,5	-7,73	0	***
corm	5,3	4,5	2,73	0,01	**
coverage5	0,2	0,22	-4,02	0	***
coverage7	0,13	0,14	-4,52	0	***
coverage10	0,08	0,08	4,1	0	***
contrast	90,1	110,2	-1,76	0,08	
homog	372,6	306,8	19,62	0	***
uniformity	236,12	181,1	5,89	0	***

Classification

- kNN classification for 2-class features (10 fold cross-validation)

feature	accuracy	precision	recall	F1-score
qual	79,4%	80,8%	78,1%	79,4%
qual/fem	86,4%	85,9%	83,4%	84,7%
qual/male	78,3%	79,8%	78,9%	79,4%
gender	77,6%	86,8%	80,4%	83,5%
gender/lay	80,6%	84,6%	83,9%	84,2%
gender/spec	78,4%	90,6%	80,7%	85,4%
imGen	57,0%	21,2%	35,9%	26,7%
imGen/spec	59,2%	27,1%	41,2%	32,7%
imGen/lay	57,5%	22,2%	37,9%	28,0%

Confusion matrix for age groups

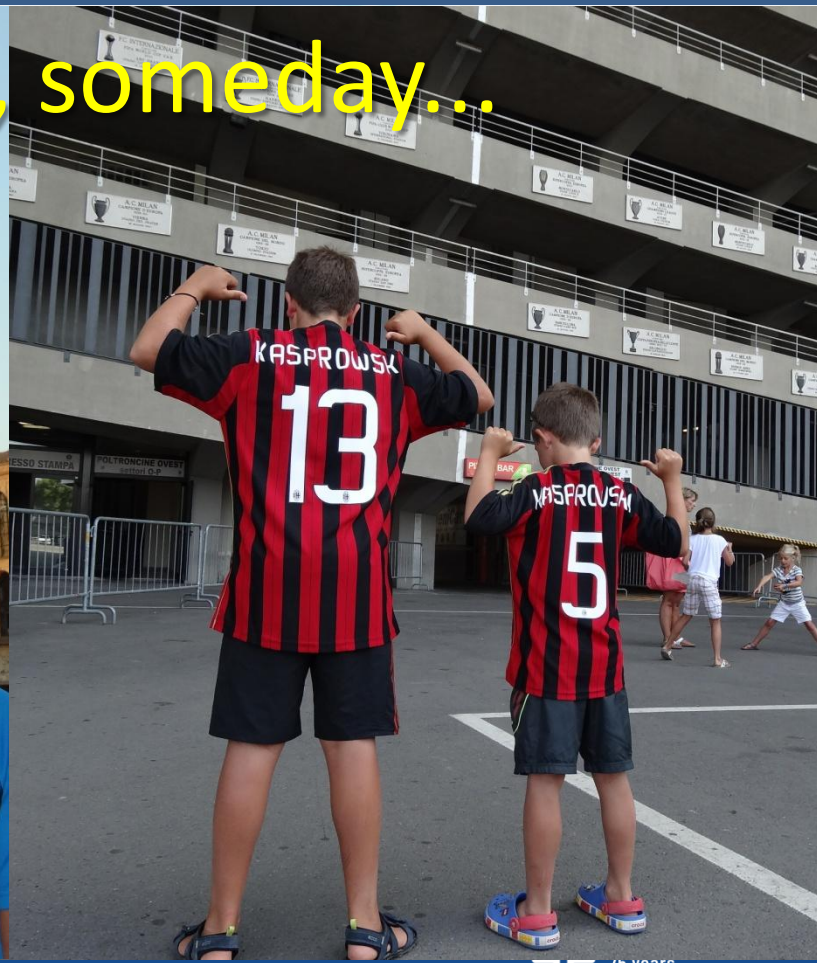
- Four groups: 20-30, 30-40, 40-50, 50+
- Group 40-50 with the best precision and recall (0.79/0.84)
- Group 50+ high recall (0.74) but low precision (0.46)

	20-30	30-40	40-50	50+
20-30	108	50	21	9
30-40	88	211	34	27
40-50	19	18	220	4
50+	2	8	2	35

Summary

- New metrics (recurrence plot and GSSP based) are useful for analysing gaze patterns
- Age, gender and qualification of the observers may be found using these metrics
- For future research more elaboration about the meaning and interpretation of these metrics is necessary

See you in Milano, someday...



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