



Yoti facial Age Estimation

White Paper | Executive summary

March 2023



Executive summary

Yoti's facial age estimation can determine a person's age by using an image of their face, with no need for a physical check of documents or human intervention. It is very accurate across all skin types and gender. It is so accurate that any business globally could accept estimated age as a reliable proof of age.

The technology is built in accordance with the GDPR principle of 'privacy by design'. An individual cannot be identified by the model and it encourages data minimisation by only needing a facial image - Yoti immediately deletes all images of users. The model cannot infer anything else about a person nor can it uniquely identify a person.

Our True Positive Rate¹ (TPR) for 13-17 year olds being correctly estimated as under 25 is 99.93% and there is no discernible bias across gender or skin tone. The TPRs for female and male 13-17 year olds are 99.90% and 99.94% respectively. The TPRs for skin tone 1, 2 and 3 are 99.93%, 99.89% and 99.92% respectively. This gives regulators globally a very high level of confidence that children will not be able to access adult content.

Our TPR for 6-11 year olds being correctly estimated as under 13 is 98.35%. The TPRs for female and male 6-11 year olds are 98.00% and 98.71% respectively. The TPRs for skin tone 1, 2 and 3 are 97.88%, 99.24% and 98.18% respectively so there is no material bias in this age group either.

Yoti's facial age estimation is performed by a 'neural network', trained to be able to estimate human age by analysing a person's face. Our technology is accurate for 6 to 12 year olds, with a mean absolute error (MAE) of 1.3 years, and of 1.4 years for 13 to 17 year olds. These are the two age ranges regulators focus upon to ensure that under 13s and 18s do not have access to age restricted goods and services.

At Yoti, we take our ethical responsibilities as a company developing new technology very seriously. The millions of faces used to train the algorithm (face image, month and year of birth only) are obtained by Yoti during the onboarding process for our apps and in accordance with GDPR or using consented data collection exercises. See page 24, Appendix.

This iteration of the algorithm continues to show improvements in accuracy. We have invested significant time and resources to reduce bias and we are now able to show that there is no material bias for age ranges between 6 and 17. We have also made significant progress on reducing bias for older females and those with a darker skin tone to ensure facial age estimation is as equitable as possible. Additionally, to meet regulatory best practice, we are beginning to retire old training and testing data.

1. True Positive Rate - the probability that an actual positive will test positive, such as an 18 year old is correctly estimated to be under 25.

Expanding the data set & improving accuracy

Our first white paper, published in December 2018, contained accuracy across the age ranges of 13-60. Since September 2021, we have published our 6-12 age range data, and from May 2022 included data for age range 6-70, published by year, gender and skin tone.

We are pleased to report the algorithm continues to show improvements in accuracy. We continue to see some small deviations in this trend, best explained by demographic changes in the underlying training and testing data (see page 24 for a detailed discussion).

Key takeaways

- TPR for 13-17 year olds correctly estimated as under 25 is 99.93%.
- TPR for 6-11 year olds correctly estimated as under 13 is 98.35%.
- Mean Absolute Errors (in years) are 2.9 for 6-70, 1.4 for 13-17 & 1.3 for 6-12.
- Users are not individually identifiable
- Helps organisations to meet Children’s Codes or Age Appropriate Design Codes
- Does not result in the processing of special category data
- Gender and skin tone bias minimised.
- Training data collected in accordance with GDPR.
- Independently tested and certified.
- A secure, privacy respecting solution that protects individuals.
- Yoti liveness and age estimation is very hard to ‘fool’.
- Over 593 million checks performed worldwide.
- Solution is fast and scales to over 25 million checks per day, or 300 checks per second.
- We are continuously improving both accuracy and usability.

Skin tones

For skin tone, our research team tagged the images using a scheme based on the widely used Fitzpatrick dermatological scale (see p27 for further information). Fitzpatrick uses six bands, from Type I (lightest) to Type VI (darkest). For the present, we have presented our data in three bands (based on Fitzpatrick Types I & II, Types III & IV, and Types V & VI).

Skin tone scale



Mean Absolute Error by age band

 Yoti facial age estimation accuracy Mean estimation error in years split by gender, skin tone and age band									
Gender	Female				Male				All
Skintone	Tone 1	Tone 2	Tone 3	All	Tone 1	Tone 2	Tone 3	All	
6-12	1.3	1.4	1.6	1.4	1.2	1.4	1.3	1.3	1.3
13-17	1.3	1.5	1.6	1.5	1.0	1.3	1.5	1.3	1.4
18-24	2.4	2.5	2.6	2.5	2.0	2.0	2.2	2.0	2.3
25-70	2.9	3.3	4.6	3.6	2.6	3.3	3.6	3.2	3.4
6-70	2.5	2.9	3.8	3.1	2.3	2.8	3.0	2.7	2.9

With age estimation, once you know you're dealing with a child, you can...

-  Turn off excessive notifications.
-  Set geolocation to off but give the child the ability to turn it on if needed.
-  Provide age-appropriate content.
-  Be certain the online community is within the same age threshold.
-  Minimise the data you collect - don't store it.
-  Shield their data. It shouldn't be used for things not in their interest.
-  Use child-friendly language to explain platforms.
-  Always be sure to treat a child like a child.

About 'Mean Absolute Error'

Yoti facial age estimation can make both positive and negative errors when estimating age (that is, it can estimate too high, or it can estimate too low). By taking 'absolute' values of each error, we mean ignoring whether the error is positive or negative, simply taking the numerical size of the error. We then take the average (or 'arithmetic mean') of all those absolute error values, producing an overall 'MAE'. A table of MAE by year can be found in the appendix on pages 28-30.

Mean Absolute Error by year

Age	Gender								
	Female				Male				All
	Skin Tone (Fitzpatrick Scale)								
	Type I & II	Type III & IV	Type V & VI	All	Type I & II	Type III & IV	Type V & VI	All	
	MAE	MAE	MAE	Average MAE	MAE	MAE	MAE	Average MAE	Average MAE
6	1.3	2.0	1.6	1.6	1.3	2.2	1.7	1.8	1.7
7	1.4	1.4	1.3	1.3	1.0	1.6	2.2	1.6	1.5
8	1.6	1.3	1.4	1.4	1.5	1.7	1.4	1.5	1.5
9	1.3	1.2	1.6	1.4	1.5	1.2	1.0	1.2	1.3
10	1.2	1.2	1.5	1.3	1.0	1.1	1.0	1.0	1.2
11	0.9	1.2	1.9	1.3	0.9	0.9	0.9	0.9	1.1
12	1.2	1.5	1.6	1.4	0.9	1.1	0.9	1.0	1.2
13	1.9	2.5	2.3	2.2	1.4	1.5	1.9	1.6	1.9
14	1.4	1.7	2.1	1.7	1.1	1.5	2.0	1.5	1.6
15	1.2	1.3	1.5	1.3	1.0	1.2	1.4	1.2	1.3
16	0.9	1.0	1.2	1.0	0.9	1.1	1.0	1.0	1.0
17	1.0	0.9	1.0	1.0	0.9	1.1	1.0	1.0	1.0
18	1.3	1.2	0.9	1.1	1.2	1.4	1.2	1.3	1.2
19	1.8	1.9	1.6	1.8	1.6	1.7	1.7	1.7	1.7
20	2.3	2.3	2.2	2.3	2.1	2.0	2.2	2.1	2.2
21	2.8	2.8	2.4	2.7	2.1	2.1	2.2	2.1	2.4
22	2.9	2.9	2.9	2.9	2.3	2.1	2.6	2.3	2.6
23	3.0	3.2	3.8	3.3	2.5	2.2	2.4	2.3	2.8
24	2.9	2.9	4.7	3.5	2.5	2.3	3.0	2.6	3.1
25	2.8	3.0	4.2	3.3	2.0	2.1	2.7	2.3	2.8
26	2.3	3.0	4.3	3.2	1.9	2.1	2.5	2.2	2.7
27	2.5	2.8	4.6	3.3	1.9	1.9	2.5	2.1	2.7
28	2.3	3.0	4.4	3.2	2.0	2.2	2.8	2.3	2.8
29	2.4	2.8	4.6	3.3	2.0	2.3	2.8	2.4	2.8
30	2.5	2.9	4.1	3.2	2.0	2.3	2.7	2.3	2.8

Mean Absolute Error by year

Age	Gender								
	Female				Male				All
	Skin Tone (Fitzpatrick Scale)								
	Type I & II	Type III & IV	Type V & VI	All	Type I & II	Type III & IV	Type V & VI	All	
	MAE	MAE	MAE	Average MAE	MAE	MAE	MAE	Average MAE	Average MAE
31	2.9	3.1	4.6	3.5	2.2	2.4	2.4	2.3	2.9
32	2.8	3.1	5.3	3.8	2.3	2.8	2.9	2.7	3.2
33	3.2	3.7	4.2	3.7	2.6	3.1	2.9	2.9	3.3
34	2.9	3.4	4.7	3.7	2.4	3.0	3.0	2.8	3.3
35	3.2	3.3	5.7	4.1	2.6	2.9	2.6	2.7	3.4
36	2.5	2.6	4.7	3.3	2.6	2.9	3.1	2.9	3.1
37	3.1	3.9	3.7	3.5	2.6	3.2	3.3	3.0	3.3
38	2.4	2.8	4.0	3.1	2.2	3.1	3.0	2.8	2.9
39	2.8	3.9	3.6	3.4	2.6	2.7	3.6	2.9	3.2
40	2.6	2.8	3.8	3.0	2.5	2.5	2.5	2.5	2.8
41	2.6	3.2	3.5	3.1	2.3	2.4	2.7	2.5	2.8
42	2.6	3.0	3.1	2.9	2.4	2.9	3.1	2.8	2.9
43	3.1	3.3	4.3	3.5	2.5	2.6	3.1	2.7	3.1
44	2.5	3.4	3.5	3.2	2.4	2.9	3.1	2.8	3.0
45	2.6	3.7	3.6	3.3	2.3	3.4	2.7	2.8	3.0
46	2.8	3.2	3.2	3.1	3.0	4.2	3.8	3.7	3.4
47	3.1	3.2	3.2	3.2	2.7	3.5	3.1	3.1	3.1
48	3.0	4.0	2.8	3.3	2.7	2.9	3.6	3.1	3.2
49	3.1	2.9	3.7	3.2	3.1	3.2	3.7	3.3	3.3
50	3.0	2.8	5.2	3.7	2.9	3.4	3.5	3.3	3.5
51	3.3	3.2	6.7	4.4	3.1	3.1	3.9	3.4	3.9
52	3.1	3.0	4.9	3.7	3.2	3.1	5.1	3.8	3.7
53	3.2	3.5	4.2	3.7	3.1	3.0	4.0	3.4	3.5
54	2.9	3.5	9.7	5.4	3.2	4.1	4.6	4.0	4.7
55	3.3	3.5	4.7	3.8	2.5	4.2	4.5	3.7	3.8

Mean Absolute Error by year

Age	Gender								
	Female				Male				All
	Skin Tone (Fitzpatrick Scale)								
	Type I & II	Type III & IV	Type V & VI	All	Type I & II	Type III & IV	Type V & VI	All	
	MAE	MAE	MAE	Average MAE	MAE	MAE	MAE	Average MAE	Average MAE
56	2.6	4.0	4.7	3.8	2.8	3.5	3.9	3.4	3.6
57	3.1	3.4	5.4	4.0	2.8	3.2	4.2	3.4	3.7
58	2.9	3.2	6.4	4.2	2.7	3.8	3.9	3.5	3.8
59	2.7	3.6	4.5	3.6	2.6	3.4	4.1	3.4	3.5
60	2.5	3.3	4.7	3.5	2.7	3.5	4.7	3.6	3.6
61	2.8	3.7	5.1	3.8	2.6	3.5	4.2	3.4	3.6
62	2.1	4.5	6.8	4.5	2.6	3.1	3.7	3.2	3.8
63	2.3	2.9	4.7	3.3	2.6	3.1	5.1	3.6	3.4
64	2.5	3.2	4.0	3.2	2.8	3.2	3.9	3.3	3.3
65	2.2	2.3	2.5	2.3	2.4	3.7	3.9	3.4	2.9
66	3.2	3.0	4.4	3.5	3.1	4.8	4.2	4.0	3.8
67	3.5	2.8	8.6	4.9	3.6	3.8	3.8	3.7	4.3
68	3.4	3.1	2.5	3.0	3.5	6.1	4.9	4.8	3.9
69	3.8	3.9		3.9	3.7	4.5	2.9	3.7	3.8
70	4.0	5.4	5.3	4.9	3.3	6.5	10.2	6.6	5.8
Avg	2.5	2.9	3.8	3.1	2.3	2.8	3.0	2.7	2.9



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