



Yoti facial Age Estimation

White Paper | Executive summary

December 2023



Executive summary

Yoti's facial age estimation technology can determine a person's age from an image of their face, with no need for a physical document check or human intervention. It is accurate across all skin types and genders.

Yoti's facial age estimation technology is built in accordance with the GDPR principle of 'privacy by design'. An individual cannot be identified by Yoti nor can we infer anything else about a person. It also encourages data minimisation as only a facial image is needed to estimate the user's age. Yoti immediately deletes all images of users.

Yoti's True Positive Rate¹ (TPR) for 13 to 17 year olds correctly estimated as under the age of 25 is 99.91% and there is no discernible bias across genders or skin tones. The TPRs for female and male 13 to 17 year olds are 99.85% and 99.96% respectively. The TPRs for skin tones 1, 2 and 3 are 99.92%, 99.89% and 99.93% respectively. Globally, regulators can be confident that users can only access content appropriate to their age.

The TPR for 6 to 12 year olds correctly estimated as under the age of 13 is 96.99%. The TPRs for female and male 6 to 12 year olds are 96.35% and 96.34% respectively. The TPRs for skin tones 1, 2 and 3 are 96.36%, 98.37% and 96.84% respectively. Therefore, there is no material bias in this age group either.

Yoti's facial age estimation is performed by a 'neural network', which is trained to be able to estimate a human's age by analysing a their face. The technology is accurate for 6 to 12 year olds, with a mean absolute error (MAE) of 1.4 years, and an MAE of 1.4 years for 13 to 17 year olds. Regulators focus on these two age ranges ensure that under 13s and under 18s cannot have access to age restricted goods and services.

When developing new technology, Yoti takes its ethical responsibilities very seriously. The data used to train the algorithm (images of faces, month and year of birth) are obtained during the onboarding process for Yoti's apps. This is done in accordance with GDPR guidelines. We also perform consented data collection exercises and purchase consented data from vetted suppliers where we require training data in efforts to ensure equality of performance across the population. See page 24, Appendix.

This iteration of the algorithm continues to show improvements in accuracy. Yoti has invested significant time and resources to reduce bias. As a result, Yoti is now able to show that there is no material bias for those aged between 6 and 17. We have made a lot of progress on accuracy for the whole population over 40, especially skin tones 2 and 3. Our aim being to ensure facial age estimation is as fair as possible. Finally, Yoti is starting to retire old training and testing data to meet regulatory standards.

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

Expanding the data set & improving accuracy

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

We are pleased to report that our algorithm continues to show improvements in accuracy. There are still 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 to 17 year olds correctly estimated as under 25 is 99.91%.
- TPR for 6 to 11 year olds correctly estimated as under 13 is 96.99%.
- Mean Absolute Errors (in years) are 2.7 for ages 6 to 70, 1.4 for ages 13 to 17 & 1.4 for ages 6 to 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 is minimised.
- Training data is 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). The Fitzpatrick scale uses six bands from Type I (lightest) to Type VI (darkest). At the moment we present 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

<div>  Yoti facial age estimation accuracy </div> <div>Mean estimation error in years split by gender, skin tone and age band</div>									
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	1.7	1.4	1.2	1.3	1.4	1.3	1.4
13-17	1.3	1.5	1.7	1.5	1.0	1.4	1.6	1.3	1.4
18-24	2.4	2.3	2.4	2.4	1.9	1.9	2.0	1.9	2.1
25-70	2.8	3.2	3.9	3.3	2.6	3.1	3.2	2.8	3.0
6-70	2.5	2.7	3.3	2.9	2.2	2.6	3.0	2.6	2.7

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



Turn off excessive notifications.



Minimise the data you collect and do not store it.



Set geolocation to off but give the child the ability to turn it on if needed.



Shield their data. It shouldn't be used for purposes not in their interest.



Provide age-appropriate content.



Use child-friendly language to explain platforms.



Be certain the online community is within the same age threshold.



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, this ignores 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, to produce 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	1.2	1.7	1.9	1.6	1.3	1.8	1.8	1.6	1.6
7	1.3	1.5	1.4	1.4	0.9	1.3	2.0	1.4	1.4
8	1.5	1.1	1.7	1.4	1.5	1.5	1.2	1.4	1.4
9	1.4	1.4	1.6	1.5	1.6	1.1	1.2	1.3	1.4
10	1.3	1.3	1.5	1.4	1.1	1.1	1.4	1.2	1.3
11	1.0	1.3	2.0	1.5	1.1	0.9	0.9	1.0	1.2
12	1.3	1.5	1.6	1.4	1.0	1.4	1.1	1.2	1.3
13	2.0	2.5	2.5	2.3	1.5	1.7	1.9	1.7	2.0
14	1.4	1.6	2.2	1.7	1.2	1.6	2.0	1.6	1.7
15	1.2	1.3	1.7	1.4	1.0	1.2	1.6	1.2	1.3
16	1.0	1.1	1.3	1.2	0.8	1.1	1.2	1.1	1.1
17	1.1	0.9	1.0	1.0	0.8	1.1	1.1	1.0	1.0
18	1.4	1.2	0.9	1.2	1.1	1.3	1.2	1.2	1.2
19	1.8	1.9	1.6	1.8	1.5	1.5	1.5	1.5	1.6
20	2.3	2.3	2.1	2.3	1.9	1.8	2.0	1.9	2.1
21	2.7	2.7	2.2	2.5	2.1	2.0	1.9	2.0	2.3
22	2.7	2.6	2.8	2.7	2.1	2.1	2.3	2.2	2.4
23	2.9	2.7	3.5	3.0	2.2	2.1	2.3	2.2	2.6
24	2.7	2.9	3.7	3.1	2.4	2.2	2.6	2.4	2.8
25	2.8	2.8	3.5	3.0	2.0	2.1	2.4	2.1	2.6
26	2.4	2.8	3.3	2.8	2.0	2.1	2.3	2.2	2.5
27	2.6	2.8	4.4	3.3	2.0	2.1	2.4	2.2	2.7
28	2.5	3.0	3.5	3.0	2.0	2.2	2.6	2.2	2.6
29	2.5	2.8	4.1	3.1	2.1	2.6	2.7	2.5	2.8
30	2.8	2.8	3.6	3.1	2.1	2.4	2.8	2.4	2.7

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	3.0	3.5	4.4	3.6	2.1	2.5	2.3	2.3	3.0
32	2.9	3.2	4.4	3.5	2.2	2.6	2.5	2.5	3.0
33	3.1	3.6	3.8	3.5	2.6	2.9	2.7	2.7	3.1
34	2.8	3.5	3.8	3.4	2.4	3.0	2.8	2.7	3.1
35	3.1	3.6	5.0	3.9	2.4	2.8	2.8	2.7	3.3
36	2.3	2.5	4.9	3.3	2.6	2.7	3.0	2.8	3.0
37	3.4	3.6	3.6	3.5	2.4	2.9	3.1	2.8	3.2
38	2.2	2.6	3.9	2.9	2.3	3.2	2.9	2.8	2.9
39	2.8	3.7	3.5	3.3	2.6	2.7	4.0	3.1	3.2
40	2.6	2.6	3.8	3.0	2.7	2.4	3.3	2.8	2.9
41	2.4	2.6	3.0	2.7	2.4	3.0	2.8	2.7	2.7
42	2.4	2.6	3.3	2.8	2.4	2.7	3.1	2.7	2.7
43	2.7	2.7	4.2	3.2	2.5	2.6	2.7	2.6	2.9
44	2.6	2.6	3.5	2.9	2.4	2.5	3.3	2.7	2.8
45	2.7	2.8	3.7	3.0	2.4	3.1	2.5	2.7	2.9
46	2.9	2.7	3.8	3.1	2.7	3.2	3.4	3.1	3.1
47	3.3	3.2	3.9	3.5	2.7	3.1	3.5	3.1	3.3
48	3.1	2.6	3.2	3.0	2.7	2.9	3.3	3.0	3.0
49	3.1	2.8	4.3	3.4	3.1	3.1	3.3	3.1	3.3
50	2.9	2.3	4.8	3.3	2.9	2.8	3.5	3.0	3.2
51	3.0	2.4	6.0	3.8	2.7	2.9	3.7	3.1	3.5
52	2.9	2.7	4.6	3.4	3.1	2.9	4.7	3.6	3.5
53	3.0	2.8	3.8	3.2	3.1	3.4	3.7	3.4	3.3
54	2.9	2.9	4.2	3.4	2.9	3.5	3.8	3.4	3.4
55	2.8	3.5	3.4	3.2	2.6	3.5	3.7	3.3	3.2

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	2.8	3.6	3.1	3.2	2.6	3.5	4.0	3.4	3.3
57	3.0	2.9	4.5	3.5	2.8	3.1	3.5	3.1	3.3
58	2.4	2.6	5.2	3.4	2.6	3.6	3.8	3.3	3.4
59	2.5	3.2	3.7	3.1	2.5	3.2	3.5	3.1	3.1
60	2.2	3.3	3.3	2.9	2.6	3.1	4.4	3.4	3.2
61	2.5	4.1	3.5	3.4	2.3	3.1	3.2	2.9	3.1
62	2.1	4.4	2.3	3.0	2.4	3.2	4.1	3.2	3.1
63	2.4	3.2	4.3	3.3	2.5	3.0	5.1	3.5	3.4
64	2.6	4.1	3.9	3.5	2.6	3.0	3.8	3.1	3.3
65	2.6	2.7	2.7	2.7	2.3	3.3	3.6	3.1	2.9
66	2.9	3.0	4.2	3.4	2.8	4.2	4.3	3.7	3.6
67	3.5	3.1	5.0	3.9	3.3	4.3	4.9	4.2	4.0
68	3.6	3.3	2.5	3.1	3.6	4.6	5.8	4.6	3.9
69	3.7	4.8		4.2	3.8	4.2	0.6	2.9	3.5
70	4.0	6.0	2.9	4.3	3.5	6.5	8.8	6.3	5.3
Avg	2.5	2.8	3.3	2.9	2.2	2.6	2.9	2.6	2.7



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