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Notice of opposition to a European patent

Date of receipt: (for internal use only)

I. Patent opposed

European patent No.	EP4295252
European application No.	EP22710525.1
Date of mention of the grant in the European Patent Bulletin (Art. 97(3), Art. 99(1) EPC)	17 December 2025
Title of the invention	OPTICAL SKIN DETECTION FOR FACE UNLOCK

II. Proprietor of the patent

First named in the patent specification	trinamiX GmbH
Opponent's or representative's reference	A2379086EPI00Afb

III. Opponent

Organisation name:	Apple Retail Germany B.V. & Co. KG
Department:	
Address:	Maximilianstraße 54 80538 Munich Germany
Country/territory of principal place of business	Germany

IV. Authorisation

1. Representative

Representative:	SAMSON & PARTNER Patentanwälte mbB
Association No.:	275
Address:	Widenmayerstr. 6 80538 BY Bayern München Germany
Telephone:	+49 (0)89 291982-0
E-mail:	email@samson-partner.de

General authorisation number (Art. 133(3) EPC):

is/are enclosed ☐

has/have been registered under No. ☐

V. Opposition is filed against

5.1 The patent as a whole ☒

5.2 Claim(s) No(s).

VI. Grounds for opposition:

6.1 Opposition is based on the following grounds:

(a) The subject matter of the European patent opposed is not patentable (Art. 100(a) EPC) because:

- it is not new (Art. 52(1); Art. 54 EPC) ☒
- it does not involve an inventive step (Art. 52(1); 56 EPC) ☒
- patentability is excluded on other grounds, namely articles ☐

(b) The patent opposed does not disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Art. 100(b) EPC; see Art.83 EPC) ☐

(c) The subject-matter of the patent opposed extends beyond the content of the application / of the earlier application as filed (Art. 100(c) EPC; see Art.123(2) EPC) ☐

VII. Facts (Rule 76(2)(c) EPC)

7.1 Presented in support of the opposition are submitted herewith on an attached document ☒

VIII. Other requests:

- Oral proceedings are hereby requested auxiliarily.

IX. Evidence presented

D1	Patent document	CN108573203 (B) , 26.01.2021 attached as: Published-Evidence-Patent-1.pdf
D1-EN	Evidence - Translation	attached as: Evidence-Tran-1.pdf
D2	Patent document	WO2020/187719 (A1) , 24.09.2020 attached as: Published-Evidence-Patent-2.pdf

X. Payment

Mode of payment	Debit from deposit account

The European Patent Office is hereby authorised, to debit from the deposit account with the EPO any fees and costs indicated on the fees section below.

Currency:	EUR
Deposit account number:	28001846
Account holder:	SAMSON & PARTNER Patentanwälte mbB

Refunds and/or compensation

Payments (refunds, compensation) should be made to EPO deposit account:	28001846
Account holder:	Samson & Partner Patentanwälte mbB

Fees	Factor applied	Fee schedule	Amount to be paid
010 Opposition fee	1	880.00	880.00
Total:		EUR	880.00

	A Forms	Details:	System file name:
A-1	Form for notice of opposition		ep-oppo.pdf

	B Attached document files	Original file name:	System file name:
B-1	1. Facts and arguments	A2379086EPI00_D OC - Opposition.pdf	FACTS_ARGMTS.pdf
B-2	1. Any annexes (other than citation) to an opposition letter -	Exhibit SP1.pdf	OTHER-1.pdf
B-3	2. Any annexes (other than citation) to an opposition letter -	Exhibit SP2.pdf	OTHER-2.pdf
B-4	3. Any annexes (other than citation) to an opposition letter -	Exhibit SP3 - Feature Analysis - claim 1.pdf	OTHER-3.pdf

	C Attached evidence files	Original file name:	System file name:

Signature(s)

Signature(s)

Place: Munich

Date:	17 September 2026
Signed by:	/Tobias Stammberger/
Association:	SAMSON & PARTNER Patentanwälte mbB
Representative name:	Dr. Tobias Stammberger
Capacity:	Representative
Function of person signing:	Representative

SAMSON & PARTNER

Patentanwälte
European Patent Attorneys
European Trade Mark Attorneys
European Design Attorneys
UPC Representatives

Dr. rer. nat. Wolfgang Lippich, Dipl.-Phys., M. Comp. Sc.
Dr. Oswald Niederkofler, Dipl.-Phys.
Dr. rer. nat. Georg Jacoby
Dr. Tobias Stammberger, Dipl.-Phys.
Dr.-Ing. Cletus von Pichler
Dipl.-Inf. Alexander Münster, LL.M.
Dipl.-Forstw. Ralf Haft, M.Com.
Dr. rer. nat. Robert Baier, M. S.
Dr. Marcus Otten, Dipl.-Phys.
Dr. rer. nat. Lucas Fischer
Of Counsel
Dipl.-Phys. Friedrich R. von Samson-Himmelstjerna
Dipl.-Phys. Michael R. A. Turi

Samson & Partner Patentanwälte mbB
Amtsgericht München PR 30
Telefon +49 (0)89 - 29 19 82 0
Fax +49 (0)89 - 29 94 65
email@samson-partner.de
www.samson-partner.de

SAMSON & PARTNER • Widenmayerstr. 6 • D-80538 München

European Patent Office

80298 Munich

Ihr Zeichen / Your Ref.:	Unser Zeichen / Our Ref.	Datum / Date:
	A2379086EPI00	17 September 2026

Patent No.:	**EP 4 295 252 B1**
Application No.:	**22710525.1**
Proprietor:	**trinamiX GmbH, 67063 Ludwigshafen am Rhein (DE)**
Opponent:	**Apple Retail Germany B.V. & Co. KG, Maximilianstraße 54, 80538 Munich (DE)**

In the name and on behalf of

Apple Retail Germany B.V. & Co. KG, Maximilianstraße 54, 80538 Munich, Germany

we herewith file

OPPOSITION

against European patent **EP 4 295 252 B1** (*"Optical Skin Detection For Face Unlock"*), which was granted to **trinamiX GmbH**, 67063 Ludwigshafen am Rhein (DE), on 17 December 2025.

The opposition is based on the grounds that the subject-matter claimed by EP 4 295 252 B1 is not novel and is not based on an inventive step (Art. 100(a), 52, 54 and 56 EPC).

The official opposition fee is paid along with the submission of this Notice of Opposition by online debit order for our deposit account held with the EPO no. 28001846.

The undersigned representative belongs to the association Samson & Partner Patentanwälte mbB; no. 275 and herewith appoints himself and the other members of the association Samson & Partner

Patentanwälte mbB; no. 275 as professional representatives of the opponent in the present opposition proceedings.

The Notice of Opposition is structured as follows:

Contents

A. Requests 3

B. Accelerated processing - Parallel litigation before the Unified Patent Court 4

C. Documents relied on 4

D. Subject-matter of the patent in suit 4

I. Claimed subject-matter 7

1. Independent Claim 1 7

E. Person skilled in the art 8

F. Lack of novelty over D1 (CN 108573203 B) 9

I. The technical teaching of D1 (CN 108573203 B) 9

II. Disclosure of the features of claim 1 by D1 12

1. Feature F1 12

2. Features F1.1, F1.1.1 13

3. Feature F1.1.2 14

4. Feature F1.2 14

5. Feature F1.2.1 15

6. Features F1.2.2, F1.2.3 16

7. Feature F1.2.4 16

8. Feature F1.2.5 17

9. Feature F1.3 18

10. Feature F1.3.1 18

11. Feature F1.3.2 19

12. Feature F1.4 20

III. Conclusion 21

G. Lack of inventive step over D1 (CN 108573203 B) in combination with D2 (WO 2020/187719 A1) 21

I. The technical teaching of D2 (WO 2020/187719 A1) 22

II. Obviousness of the subject-matter of claim 1 25
1. Feature F1.2.1 25
2. Feature F1.2.4 26
3. Feature F1.3.1 27
4. Motivation of the skilled person 28
III. Conclusion 31
H. Dependent claims 31
I. Claim 2 31
II. Claim 3 32
III. Claim 4 32
IV. Claim 5 32
V. Claim 6 33
VI. Claim 7 33
VII. Claim 8 34
VIII. Claim 9 34
IX. Claim 10 35
I. Independent claims 11 to 15 35

A. Requests

1. Herewith it is requested

   (1) to revoke the patent EP 4 295 252 B1 in its entirety (claims 1 – 15), and

   (2) on an auxiliary basis in case the above request (1) is not granted, to schedule Oral Proceedings.

   (3) to **accelerate** the processing of the opposition pursuant to the Notice from the European Patent Office dated 10 March 2023 concerning accelerated processing before the opposition divisions in case of parallel litigation (OJ EPO 2023, A99), in particular by:

   (i) inviting the proprietor to comment on the opposition within three months (instead of the usual four months),

   (ii) issuing summons within two months of receipt of the proprietor's reply, and

   (ii) summoning the parties at minimum notice (Rule 115(1) EPC).

2. The grounds and evidence justifying the above request (1) will be presented below. In summary, patent EP 4 295 252 B1 shall be revoked, because the claimed subject-matter

   a) lacks novelty (Art. 54 and 100(a) EPC),

   b) does not involve an inventive step (Art. 56 and 100(a) EPC).

3. Before turning to request (1), we will present the grounds and evidence justifying the above acceleration request (3).

B. Accelerated processing - Parallel litigation before the Unified Patent Court

4. On 10 September 2026, the opponent (defendant 3) was served with an infringement action concerning the patent in suit, EP 4 295 525, brought by the patent proprietor, trinamiX GmbH, Industriestraße 35, 67063 Ludwigshafen am Rhein, before the Unified Patent Court, Local Division Mannheim, under case reference UPC-CFI-00003171/2026.

5. We enclose, as evidence of the institution of these proceedings:

- Exhibit SP1: Excerpt from the statement of claim filed before the Unified Patent Court, Local Division Mannheim, showing the parties, the patent in suit and the date of filing (3 September 2026);
- Exhibit SP2: Letter of service of the Unified Patent Court, Local Division Mannheim, dated 7 September 2026, confirming service of the statement of claim on the opponent.

C. Documents relied on

6. We will refer to the following documents:

D1: CN 108573203 B, published on 26 January 2021,

D1-EN: English translation of document D1 (taken from the prosecution file of the patent's divisional EP 4 546 296; the text in the drawings was machine translated), and

D2: WO 2020/187719 A1, published on 24 September 2020.

Documents D1 and D2 were published before the priority date of EP 4 295 252 B1 and are therefore prior art within the meaning of Art. 54(2) EPC. Both documents are mentioned in the patent's specification [EP'252, para. 10, 61, 176] but have not been discussed during prosecution.

D. Subject-matter of the patent in suit

7. The patent in suit, European patent EP 4 295 252 B1 (hereinafter: "EP'252"), lies in the field of biometric authentication and, more specifically, in the field of optical face authentication ("face unlock") for securing access to information technology systems and mobile terminals. Addressed are both classical access control – mobile phone, building,

machine, motor vehicle – and downstream security functions such as the launching of security-relevant applications [EP'252, para. 1; para. 2; para. 6; para. 132].

8. The specific sub-field addressed is presentation attack detection (PAD) in the context of face authentication. According to the specification, the first generation of automatic face recognition tools works with digital camera images or image streams, extracts characteristic features by two-dimensional image processing and generates face templates therefrom using machine learning methods. The second generation replaces hand-crafted image features by deep convolutional neural networks (CNN) [EP'252, para. 3]. Both approaches can be attacked, for instance with a high-quality photograph, which is the origin of presentation attack detection [EP'252, para. 4].

9. The specification itself describes as known: early PAD approaches which record image sequences and examine time-dependent features such as small head movements or eye blinks; the use of near infrared (NIR) cameras in order to exclude displays as an attack instrument, since displays emit only in the visible spectral range; and 3D cameras which distinguish planar photographs or tablets showing playback videos from a three-dimensional face [EP'252, para. 4]. High-quality masks – 3D printed, silicone or latex masks, or a spatial arrangement of 2D photographs – defeat both the movement-based liveness detection and the 3D cameras [EP'252, para. 4; para. 8]. As a way out, the specification names a PAD system capable of classifying human skin from other materials [EP'252, para. 4].

10. The specification formulates the **object** it sets itself as being to provide devices and methods which meet the technical challenges of known devices and methods. While simple presentation attacks with photographs and videos can be detected, an approach for the reliable detection of presentation attacks with 3D face masks is said to be lacking:

> *"Specifically, another layer of security is needed to enable the replacement of passphrases/PIN codes by biometric features derived from faces to unlock digital devices. Moreover, a method is needed that operates fully agnostic with respect to different skin types originating from different ethnic origins."*
>
> [EP'252, para. 11]

11. In summary form the specification states:

> *"Summarizing, current methods for face unlock do not provide the ability to reliably detect spoof attacks by 3D masks and perform this task at a speed below human detection limit."*
>
> [EP'252, para. 8]

12. Added to this are the further objectives of high speed – detection below the human perception limit –, low computational and energy expenditure, and dispensing with the evaluation of several consecutive video frames [EP'252, para. 6; para. 7].

13. The **solution** offered consists in a three-stage checking chain whose results decide cumulatively on the authentication, and in the proposition that two of the three checks can be obtained from a single camera image of the same projected illumination pattern [EP'252, para. 17; para. 130].

- In a **first stage**, a camera records a first, two-dimensional image of a scene suspected to comprise the face. In that image the face is detected by identifying at least one pre-defined or pre-determined geometrical feature characteristic for faces. This feature at the same time defines an image region which serves as the evaluation window for the two following stages [EP'252, para. 17; para. 34; para. 40; para. 60].

- In a **second stage**, an illumination pattern comprising a plurality of illumination features is projected onto the scene and a second image ("reflection image") is recorded with the same camera. Each reflection feature of that image carries a beam profile. From the beam profile of at least one reflection feature located inside the face region determined in the first stage, a first beam profile information and, from it, a material property is determined. If that property corresponds to a property characteristic for skin, the detected face is characterized as skin [EP'252, para. 17; para. 61; para. 63; para. 102].

- In a **third stage**, a second beam profile information is determined from the beam profiles of at least four reflection features located inside the same image region, and from it at least one depth level. If that depth level deviates from a pre-determined or pre-defined depth level of plane objects, the face is characterized as 3D object [EP'252, para. 17; para. 104; para. 127; para. 129].

- In a **fourth stage**, the detected face is authenticated by means of an authentication unit only if both conditions are met: skin and 3D object [EP'252, para. 17; para. 131].

14. The advantages which the specification attributes to this sequence of steps are, first, the shared data basis of steps b) and c) – *"Since the same computational pipeline can be used to generate the input data for the skin classification and the generation of the 3D point cloud, both properties can be calculated from the same frame with low computational effort."* [EP'252, para. 130] – and, second, their cumulative linkage: *"The combination of steps b) and c) may allow strengthening reliability of the authentication with respect to attacks. 3D features can be combined with material features to increase the security level."* [EP'252, para. 130]. The independence from ethnic origin, by contrast, is attributed by the specification not to the sequence of steps but to the shifting of the laser wavelength into the NIR range, where the differences are said to be minimal at 940 nm [EP'252, para. 45; para. 136].

15. The solution thus outlined in the specification is reflected in the claimed subject-matter discussed below.

I. Claimed subject-matter

16. EP'252 contains six independent claims in four claim categories. Claim 1 is a method claim ("Method for face authentication") and forms the core of the teaching. Claim 11 is a computer program claim which refers to the method according to any one of the preceding claims and configures the program for carrying out and/or executing at least steps a) to d) of the method. Claims 12 and 13 concern a computer-readable storage medium and a non-transitory computer-readable medium respectively, in each case with instructions for executing at least steps a) to d) of the method according to any one of claims 1 to 10. Claim 14 is an apparatus claim (mobile device comprising a camera, an illumination unit and a processing unit) which is configured to carry out at least steps a) to c) and optionally step d) of the method according to any one of claims 1 to 10. Claim 15 is a use claim (use of the method according to any one of claims 1 to 10 for detecting biometric presentation attacks). Claims 11 to 15 each refer to claims of a different category and are therefore – irrespective of their back-reference – independent claims. In substance they stand to one another in the relationship of corresponding categories directed to the same method concept: claim 1 defines the sequence of steps, claims 11 to 13 its embodiment in program terms, claim 14 the hardware embodiment and claim 15 the intended purpose as PAD. Claims 2 to 10 are dependent on claim 1. Claim 1 is not drafted in two-part form; it contains no characterizing clause.

17. A number of aspects emphasized in the description are the subject-matter of the dependent claims: the wavelength in the NIR range is the subject of claim 8 [EP'252, Claim 8]; the enrollment and the comparison of the first image with a stored 2D image of the user are the subject of claim 3 [EP'252, Claim 3; para. 133]; the release of access to a device is the subject of claim 2 [EP'252, Claim 2; para. 132]; the determination of a plurality of second images is the subject of claim 9 [EP'252, Claim 9; para. 53]; and the parameterized skin classification model trained by machine learning is the subject of claims 4 and 5 [EP'252, Claim 4; Claim 5; para. 99-101]. The presentation which follows relate to independent claim 1.

18. The solution thus claimed is defined in independent claim 1 of the patent in suit as follows:

1. Independent Claim 1

19. Broken down in its features, claim 1 reads as follows:

Feature	Wording
F1	Method for face authentication comprising the following steps:
F1.1	a) at least one face detection step (110),
F1.1.1	wherein the face detection step (110) comprises determining at least one first image by using at least one camera (112), wherein the first image comprises at least one two-dimensional image of a scene suspected to comprise the face,
F1.1.2	wherein the face detection step (110) comprises detecting the face in the first image by identifying in the first image at least one pre-defined or pre-determined geometrical feature characteristic for faces by using at least one processing unit (114);
F1.2	b) at least one skin detection step (116),
F1.2.1	wherein the skin detection step (116) comprises projecting at least one illumination pattern comprising a plurality of illumination features on the scene by using at least one illumination unit (118) and determining at least one second image using the at least one camera (112),
F1.2.2	wherein the second image comprises a plurality of reflection features generated by the scene in response to illumination by the illumination features,
F1.2.3	wherein each of the reflection features comprises a beam profile,
F1.2.4	wherein the skin detection step comprises determining a first beam profile information of at least one of the reflection features located inside an image region of the second image corresponding to an image region of the first image comprising the identified geometrical feature by analysis of its beam profile and determining at least one material property of the reflection feature from the first beam profile information by using the processing unit (114),
F1.2.5	wherein the detected face is characterized as skin if the material property corresponds to at least one property characteristic for skin;
F1.3	c) at least one 3D detection step (120),
F1.3.1	wherein the 3D detection step (120) comprises determining a second beam profile information of at least four of the reflection features located inside the image region of the second image corresponding to the image region of the first image comprising the identified geometrical feature by analysis of their beam profiles and determining at least one depth level from the second beam profile information of said reflection features by using the processing unit (114),
F1.3.2	wherein the detected face is characterized as 3D object if the depth level deviates from a pre-determined or pre-defined depth level of plane objects;
F1.4	d) at least one authentication step (122), wherein the authentication step (122) comprises authenticating the detected face by using at least one authentication unit if in step b) (116) the detected face is characterized as skin and in step c) (120) the detected face is characterized as 3D object.

20. For the convenience of the Opposition Division and the parties, we submit the feature analysis of claim 1 separately as

– Exhibit SP3 –.

E. Person skilled in the art

21. The skilled person is here a physicist, engineer or computer scientist with a completed university degree at master level, who has several years of relevant professional experience

in the development department of a manufacturer of face recognition systems using optical sensors, camera modules and/or laser light sources. The skilled person is thus familiar with related image processing and pattern recognition methods including machine learning, in particular for face detection and face authentication.

F. Lack of novelty over D1 (CN 108573203 B)

I. The technical teaching of D1 (CN 108573203 B)

22. Document D1 was published on 26 January 2021 before the priority date of EP'252 and is therefore prior art within the meaning of Art. 54(2) EPC. In the following analysis, all references to D1 are made relative to its Englisch translation (document D1-EN).

23. D1 lies in the field of image processing and, more particularly, of identity authentication: *"The present invention relates to the field of image processing, and more specifically to an identity authentication method and device and storage medium."* [D1-EN, para. 2]. It is concerned with the secured authentication of persons in transactional applications, in particular e-commerce, mobile payment and the opening of bank accounts [D1-EN, para. 5]. The authentication means hitherto customary in those applications are described as inadequate: passwords must be memorized and re-entered, and once stolen cause loss of privacy or property, whereas identity documents *"are easy to be forged or fraudulently used, and their security is low"* [D1-EN, para. 5].

24. The solution proposed by D1 is the combination of a document-based information authentication with a biometric liveness check, both results being merged into a single decision on the legitimacy of the identity:

> *"According to one aspect of the present invention, an identity authentication method is provided. The method includes: obtaining the personal identification information of the person to be authenticated; judging whether the personal identification information is authenticated information to obtain the information authentication result; performing a living test on the person to be authenticated to obtain the living test result; and at least according to the information authentication result and the living body The test result determines whether the identity of the person to be authenticated is legal."*
>
> [D1-EN, para. 8]; identically at [D1-EN, Claim 1] and [D1-EN, para. 303]

25. The decision logic is cumulative: *"if any one of the information authentication result and the living body test result is 0, it can be considered that the identity of the person to be authenticated is illegal, that is, the authentication of the person to be authenticated has failed."* [D1-EN, para. 327]. The method is deployed *"at the image collection terminal of a financial system such as a bank management system or at a mobile terminal such as a smart phone or a tablet computer"* [D1-EN, para. 332].

26. Within the liveness detection, D1 distinguishes expressly between security levels and assigns the optical, hardware-supported variant to the applications with elevated security requirements:

> *"The above-mentioned methods of performing live body detection based on the actions of the human face or using the skin elasticity classifier are mainly aimed at some application scenarios with weaker safety requirements. For some application scenarios with higher security requirements, you can choose the way of live detection based on special hardware. For example, a binocular camera may be used to collect face images illuminated by structured light, so as to use the collected face information and structured light illumination information for living body detection."*
>
> [D1-EN, para. 413]

27. The attack scenario against which this branch is directed is the three-dimensional mask: the structured-light evaluation *"can effectively defend against mask attackers"* [D1-EN, para. 414], and liveness verification based on light reflection characteristics alone can be defeated by *"a three-dimensional simulation mask attack"* [D1-EN, para. 444]. The problem addressed in these passages is thus the same as that of EP'252, namely the reliable rejection of presentation attacks using 3D masks [EP'252, para. 4; para. 8].

28. The teaching relevant here is set out in a single contiguous passage at [D1-EN, para. 412]–[D1-EN, para. 417], with the device counterpart at [D1-EN, para. 209]. Its starting point is:

> *"According to the embodiment of the present invention, step S230 (S340 and S350, or S430 and S440) may include: acquiring a face image collected by a binocular camera on the face of the person to be authenticated under structured light irradiation; according to the face image Determine whether the face of the person to be authenticated is a living body to obtain the result of the living body detection."*
>
> [D1-EN, para. 412]

29. The apparatus for this is described as follows: *"the identity authentication device further includes a structured light source and a binocular camera, wherein the structured light source is used to emit structured light to the face of the person to be authenticated; the binocular camera is used to target the person to be authenticated under the illumination of the structured light. The face collects the face image"* [D1-EN, para. 209]; corresponding statements appear at [D1-EN, para. 30; para. 75; para. 119; para. 163; para. 256].

30. From that recording, D1 derives first a material statement. A detection parameter representing the degree of subsurface scattering on the face is determined and compared with a predetermined threshold:

> *"In one example, the detection parameter indicating the degree of subsurface scattering of the structured light on the face of the person to be authenticated can be determined based on the collected face image illuminated by the structured light, and then can be based on the detection parameter and the predetermined parameter Threshold, to determine*

> *whether the face of the person to be authenticated is a living body. Since 3D masks and other fake faces have different degrees of subsurface scattering from real faces (the stronger the subsurface scattering, the smaller the image gradient and the smaller the degree of diffusion), for example, those made of general paper or plastic The degree of subsurface scattering of the mask is much weaker than that of the real face, while the degree of subsurface scattering of the mask made of general silica gel is much stronger than that of the real face. Therefore, the false face can be distinguished by judging the degree of image diffusion. With real human face, it can effectively defend against mask attackers."*
>
> [D1-EN, para. 414]

31. The quantities evaluated are thus the image gradient and the degree of diffusion of the light spots on the face, that is, the spatial intensity behaviour of the individual spot.

32. The same material statement is obtained from the spot pattern and is there designated, in the words of the claim of EP'252, as a material property:

> *"Different material structures can form different spot patterns under structured light. According to the light spot pattern, the texture information of the human face can be obtained, that is, the material properties of the human face surface. If it is found that the texture information of the face of the person to be authenticated does not conform to the distribution law of human skin texture, it is determined that the face of the person to be authenticated does not belong to a living body, and it is judged as a mask attack."*
>
> [D1-EN, para. 416]

33. Secondly, D1 derives a depth statement from the same recording and requires both statements to be combined, because the material criterion alone can be satisfied by a skin-imitating mask:

> *"Since the attacker can use a mask made of imitation human skin to carry out the attack, even if the texture information of the person to be authenticated conforms to the distribution law of human skin texture, it may not be possible to determine that the face of the person to be authenticated is a living body, so it can be combined The depth information judges whether the person's face is a living body. The depth information of the face of the person to be authenticated can be obtained from the face images collected in two different perspectives. It should be understood that a real human face usually has ups and downs. For example, the coordinate depths of the eyes and nose are different, and the difference is large. However, a mask made of imitation human leather has very little ups and downs. The coordinate depth gap is very small. Therefore, combining the depth information can further determine whether the face of the person to be authenticated belongs to a living body."*
>
> [D1-EN, para. 416]

34. The passage closes with an express synthesis of material evaluation and depth evaluation from one and the same structured-light recording:

> *"Therefore, in the embodiment of the present invention, a binocular camera and structured light can be combined, and a 3D face with a structured light pattern can be collected by the binocular camera, and then*

> *according to the degree of subsurface scattering of the structured light on the 3D face, or combined with the human. The depth information of the face and the light spot pattern formed by the structured light on the face are used for living body detection."*
>
> [D1-EN, para. 417]

35. Independently of the liveness variant chosen, D1 operates with a face detection model and a facial key-point localization model, which it introduces at method level: *"the identity authentication method 200 (300, 400) may further include: obtaining a sample face image, where the position of the face and the position of the key points of the face in the sample face image are already marked; and Use sample face images for neural network training to obtain a face detection model and a face key point location model."* [D1-EN, para. 402]. The key points are geometrically interpretable facial landmarks: *"The key point can be any point on the face, such as the corner of the left eye, the tip of the nose, and the corner of the left lip. Of course, the key point can also be a face contour point."* [D1-EN, para. 400]. From the face position and the key-point positions the document derives image regions of the face: *"the face area can be divided into a series of triangular fragments according to the position of the face and the position of key points, and the triangular fragments image blocks located in the chin, cheekbones, and cheeks can be taken as the face skin area"* [D1-EN, para. 400]. A generic preliminary stage precedes every liveness variant and performs face detection on a plain camera image: *"the mobile terminal can collect real-time images through a camera and perform face detection. Face detection can obtain a face area, which is an image block containing a face."* [D1-EN, para. 472]. Its general applicability is stated at [D1-EN, para. 466]. The recording device is a camera [D1-EN, para. 301], the evaluation is performed by a processor [D1-EN, para. 297], and the decision on legitimacy is taken by the identity determination module 1040 [D1-EN, para. 502].

II. Disclosure of the features of claim 1 by D1

1. Feature F1

> *"Method for face authentication comprising the following steps:"*

36. D1 is directed to the authentication of a person, and the liveness detection within it verifies whether the imaged face is a real human face or an attack instrument: *"Determine whether the face of the person to be authenticated is a living body to obtain the result of the living body detection"* [D1-EN, para. 412]. The attack instruments expressly addressed are 3D masks [D1-EN, para. 414] as well as photographs and screen playbacks [D1-EN, para. 438]. Both alternatives of the definition of face authentication given in EP'252 [EP'252, para. 16] are thereby realized: the object is verified as a real human face, and an identity is verified in addition, since the document compares the document photograph with the

captured face [D1-EN, para. 366] and finally decides on the legitimacy of the identity [D1-EN, para. 8; Claim 1; para. 303].

37. Feature F1 is therefore disclosed in D1.

2. Features F1.1, F1.1.1

> *"a) at least one face detection step (110),"*
>
> *"wherein the face detection step (110) comprises determining at least one first image by using at least one camera (112), wherein the first image comprises at least one two-dimensional image of a scene suspected to comprise the face,"*

38. D1 performs a face detection step. The liveness detection module comprises a dedicated *"face detection sub-module, used to detect the face in the face image"* [D1-EN, para. 70]; the method-level counterpart is *"detecting the face in the face image"* [D1-EN, para. 391]. In the generic preliminary stage preceding every liveness variant, face detection is carried out on a real-time image and yields the face region: *"the mobile terminal can collect real-time images through a camera and perform face detection. Face detection can obtain a face area, which is an image block containing a face."* [D1-EN, para. 472]. The step serves the same function as in EP'252, since the face region so obtained is the basis for the delimitation of the facial regions used for the subsequent evaluation [D1-EN, para. 400].

39. The image underlying that detection is captured with a camera. The recording device is expressly a camera: *"The image capture device 110 may be a camera."* [D1-EN, para. 301]; the face image is *"collected by the image acquisition device 110 (for example, a camera) included in the electronic device 100"* and transferred to the processor [D1-EN, para. 325]. The preliminary stage acquires *"a real-time image collected for the face of the person to be authenticated"* [D1-EN, para. 471]. That real-time image is a planar camera image of a mobile terminal and thus carries information on transverse coordinates, that is, height and width [EP'252, para. 33]; the document displays it on the screen together with the detected face region [D1-EN, para. 471; para. 482], which presupposes a planar image. The minimum hardware configuration of camera and processor is shown in Fig. 1 of D1 (image capture device 110, processor 102).

40. At the time of capture it is not established that the image contains a face, since the face region must first be found by face detection and may fail to lie in the preset region: *"if the face area is not located in the preset area ... it is determined that the image acquisition condition does not meet the preset requirement"* [D1-EN, para. 471]. The image therefore covers a spatial region in which a face is expected, together with its surroundings, exactly as described in [EP'252, para. 33].

41. Features F1.1 and F1.1.1 are therefore disclosed in D1.

3. Feature F1.1.2

> *"wherein the face detection step (110) comprises detecting the face in the first image by identifying in the first image at least one pre-defined or pre-determined geometrical feature characteristic for faces by using at least one processing unit (114);"*

42. D1 detects the face by identifying geometrically interpretable facial landmarks. It employs a face detection model and a facial key-point localization model which supply the face position and the key-point positions: *"the face image of the person to be authenticated before performing the live action can be input into the trained face detection model and the face key point positioning model respectively to obtain the face position (such as the coordinates of the face contour point) and the key point position respectively"* [D1-EN, para. 400]. The key points are geometry-based features of the face and of its components: *"The key point can be any point on the face, such as the corner of the left eye, the tip of the nose, and the corner of the left lip. Of course, the key point can also be a face contour point."* [D1-EN, para. 400]. That is precisely the class of features which EP'252 describes as a *"geometry-based feature which describe the shape of the face and its components, in particular one or more of nose, eyes, mouth or eyebrow and the like"* [EP'252, para. 40].

43. The features so identified are fixed in advance. The catalogue of key points is laid down in the training data set: *"a series of key points such as the corners of the eyes, the corners of the mouth, the wings of the nose, the highest point of the cheekbones, etc., and the positions of the people can be manually marked in each sample face image"* [D1-EN, para. 403]; correspondingly, the sample face images are ones in which *"the position of the face and the position of the key points of the face in the sample face image are already marked"* [D1-EN, para. 402]. The catalogue is thus determined before the evaluation and is not generated only in the course of it.

44. The identification is performed by the processing unit, namely the processor of the electronic device, *"a central processing unit (CPU) or another form of processing unit with data processing capability and/or instruction execution capability"* [D1-EN, para. 297], on which the liveness detection module runs [D1-EN, para. 501]; a server-side implementation is described in addition [D1-EN, para. 530].

45. Feature F1.1.2 is therefore disclosed in D1.

4. Feature F1.2

> *"b) at least one skin detection step (116),"*

46. Within the structured-light variant, D1 performs a step whose function is the discrimination of human skin from other materials. It determines the material property of the facial surface from the structured-light image and compares it with the behaviour characteristic of human

skin: *"According to the light spot pattern, the texture information of the human face can be obtained, that is, the material properties of the human face surface. If it is found that the texture information of the face of the person to be authenticated does not conform to the distribution law of human skin texture, it is determined that the face of the person to be authenticated does not belong to a living body"* [D1-EN, para. 416]. The materials to be discriminated are named: masks of paper, plastic and silicone [D1-EN, para. 414] and masks of imitation skin [D1-EN, para. 416]. This corresponds to the enumeration of the materials to be discriminated in [EP'252, para. 63].

47. Feature F1.2 is therefore disclosed in D1.

5. Feature F1.2.1

> *"wherein the skin detection step (116) comprises projecting at least one illumination pattern comprising a plurality of illumination features on the scene by using at least one illumination unit (118) and determining at least one second image using the at least one camera (112),"*

48. The illumination unit is the structured light source: *"the structured light source is used to emit structured light to the face of the person to be authenticated"* [D1-EN, para. 209]. That the projected pattern comprises a plurality of illumination features follows from the spot pattern it produces on the face, which the document evaluates: *"the spot pattern formed by the face of the person to be authenticated under the irradiation of structured light can also be obtained"* [D1-EN, para. 415], and *"Different material structures can form different spot patterns under structured light"* [D1-EN, para. 416]. A pattern of spots comprises more than one at least partially extended feature within the meaning of [EP'252, para. 51]..

49. The second image is captured under that pattern illumination: *"acquiring a face image collected by a binocular camera on the face of the person to be authenticated under structured light irradiation"* [D1-EN, para. 412].

50. That second image is captured with the same recording device as the first. D1 uses one and the same term, "face image", for the generic recording of step S230 [D1-EN, para. 323] and for the structured-light recording [D1-EN, para. 412], and describes the recording device for face images generally as the image acquisition device or camera of the mobile terminal [D1-EN, para. 301; para. 325]. It locates that device expressly on the user-facing side of the terminal: *"the image acquisition device is a camera of the mobile terminal on the same side of the display screen (for example, a front camera)"* [D1-EN, para. 433]. Both recordings are images of the user's face taken from that same side, at the same distance and in the same pose, the user being required to remain still during the liveness step [D1-EN, para. 489]; and the document is expressly directed to an implementation on existing mobile terminals which *"is not restricted by external conditions"* [D1-EN, para.

433]. A binocular assembly used functionally as a single recording device for both images is itself a camera.

51. Feature F1.2.1 is therefore disclosed in D1.

6. Features F1.2.2, F1.2.3

> *"wherein the second image comprises a plurality of reflection features generated by the scene in response to illumination by the illumination features,"*
>
> *"wherein each of the reflection features comprises a beam profile,"*

52. The features evaluated in the second image are the light spots formed on the face under the structured-light illumination: *"the spot pattern formed by the face of the person to be authenticated under the irradiation of structured light can also be obtained"* [D1-EN, para. 415]. The causal link required by the claim, namely generation by the scene in response to the illumination, is expressed in *"formed by the face ... under the irradiation of structured light"*, and that the appearance of those features depends on the remitting surface is stated expressly: *"Different material structures can form different spot patterns under structured light"* [D1-EN, para. 416]. The plurality follows from the term "spot pattern", which presupposes several spots, and from the fact that the document derives from that pattern a statement about the distribution of the skin texture over the face [D1-EN, para. 416], which is possible only with several spots.

53. Each of those spots is present in the image as an intensity distribution extending over pixels. D1 assesses the spots by reference to their image gradient and their degree of diffusion: *"the stronger the subsurface scattering, the smaller the image gradient and the smaller the degree of diffusion"*, and *"the false face can be distinguished by judging the degree of image diffusion"* [D1-EN, para. 414]. Both quantities are properties of the spatial intensity behaviour of the imaged spot: a gradient exists only where the intensity varies from pixel to pixel, and a degree of diffusion describes the spatial spreading of the intensity of the individual spot. The same follows from the texture information derived from the spot pattern [D1-EN, para. 416], which is image information about the appearance of the spots and hence about their intensity distribution.

54. Features F1.2.2 and F1.2.3 are therefore disclosed in D1.

7. Feature F1.2.4

> *"wherein the skin detection step comprises determining a first beam profile information of at least one of the reflection features located inside an image region of the second image corresponding to an image region of the first image comprising the identified geometrical feature by analysis of its beam profile and determining at least one material property of the*

reflection feature from the first beam profile information by using the processing unit (114),"

55. D1 determines from the structured-light image a detection parameter representing the degree of subsurface scattering, the quantities analysed being the image gradient and the degree of diffusion of the spots: *"the detection parameter indicating the degree of subsurface scattering of the structured light on the face of the person to be authenticated can be determined based on the collected face image illuminated by the structured light"* [D1-EN, para. 414]. Further, texture information is obtained from the spot pattern [D1-EN, para. 416]. D1 does not measure any light transit time; it evaluates the spatial intensity behaviour of the spots.

56. The material property is determined: *"According to the light spot pattern, the texture information of the human face can be obtained, that is, the material properties of the human face surface."* [D1-EN, para. 416]. The degree of subsurface scattering is likewise a material property. The determination is carried out by the processing unit, that is, the processor [D1-EN, para. 297; para. 501].

57. The evaluated reflection features lie inside the image region of the pattern image which corresponds to the region of the first image containing the identified geometrical feature. The parameter which D1 forms is defined as a property of the face and of nothing else: the detection parameter relates to the subsurface scattering *"on the face of the person to be authenticated"* [D1-EN, para. 414], and the texture information is that *"of the face of the person to be authenticated"* [D1-EN, para. 416]. The document itself supplies the delimitation of that region and treats it as available knowledge: face detection on the plain real-time image yields *"a face area, which is an image block containing a face"* [D1-EN, para. 472], and that region is refined by means of the pre-defined key points down to the individual facial regions: *"the triangular fragments image blocks located in the chin, cheekbones, and cheeks can be taken as the face skin area"*, whereby *"The extraction of the skin area image can be realized based on the existing face detection and face key point location algorithms."* [D1-EN, para. 400]. Where the plain image and the pattern image originate from the same camera in the same pose, the region of the pattern image corresponding to the region of the first image follows directly from the identity of the pixel coordinates.

58. Feature F1.2.4 is therefore disclosed in D1.

8. Feature F1.2.5

"wherein the detected face is characterized as skin if the material property corresponds to at least one property characteristic for skin;"

59. D1 states the decision rule in both directions and refers it to the face of the person to be authenticated. The reference quantity is the behaviour characteristic of human skin: *"If it is found that the texture information of the face of the person to be authenticated does not conform to the distribution law of human skin texture, it is determined that the face of the person to be authenticated does not belong to a living body, and it is judged as a mask attack."* [D1-EN, para. 416]. Conversely, where the material property conforms to the distribution characteristic of human skin, the face is characterized as skin; that reading is confirmed by the following sentence, which addresses the case of conformity in terms: *"even if the texture information of the person to be authenticated conforms to the distribution law of human skin texture"* [D1-EN, para. 416].

60. That the correspondence is established by a criterion fixed in advance is stated expressly: *"can be based on the detection parameter and the predetermined parameter Threshold, to determine whether the face of the person to be authenticated is a living body"* [D1-EN, para. 414]. D1 determines the reference empirically from the differing subsurface scattering of paper, plastic and silicone masks as compared with real skin [D1-EN, para. 414].

61. Feature F1.2.5 is therefore disclosed in D1.

9. Feature F1.3

"c) at least one 3D detection step (120),"

62. D1 evaluates the depth relief of the face and thereby distinguishes a spatially structured face from a quasi-planar attack instrument: *"It should be understood that a real human face usually has ups and downs. For example, the coordinate depths of the eyes and nose are different, and the difference is large. However, a mask made of imitation human leather has very little ups and downs. The coordinate depth gap is very small."* [D1-EN, para. 416]. The three-dimensionality of the face is designated as the discriminating criterion against planar attack instruments: display screens and photographs *"are usually flat"* and *"lack the three-dimensional characteristics of a human face"* [D1-EN, para. 438]; the granted claim of D1 likewise names the *"three-dimensional characteristics of the face"* as an evaluation criterion [D1-EN, Claim 1].

63. Feature F1.3 is therefore disclosed in D1.

10. Feature F1.3.1

"wherein the 3D detection step (120) comprises determining a second beam profile information of at least four of the reflection features located inside the image region of the second image corresponding to the image region of the first image comprising the identified geometrical feature by analysis of their beam profiles and determining at least one depth level

> *from the second beam profile information of said reflection features by using the processing unit (114),"*

64. D1 determines a depth statement about the face from the same recording that carries the spot pattern: *"the depth information of the face of the person to be authenticated can be obtained according to the face image"* [D1-EN, para. 415]. The recording on which that determination operates is expressly the face bearing the projected pattern: *"a 3D face with a structured light pattern can be collected by the binocular camera, and then according to the degree of subsurface scattering of the structured light on the 3D face, or combined with the human. The depth information of the face and the light spot pattern formed by the structured light on the face are used for living body detection"* [D1-EN, para. 417]. The determination is carried out by the processor [D1-EN, para. 297].

65. On that route the depth value of each spot follows from its imaged position, that is, from its centre of intensity. The face images are captured from two viewpoints [D1-EN, para. 416]; the matching primitives in a pattern-illuminated arrangement of that kind are the projected spots, since the face itself offers too little intrinsic texture, and the depth is accordingly computed from the positions of the reflection features, and hence from their centres of intensity.

66. The number of reflection features evaluated exceeds four. A spot pattern covering a face contains substantially more than four spots, and the criterion of D1 compares the coordinate depth at the eyes and at the nose and assesses the relief across the whole of the face [D1-EN, para. 416], which requires depth values at several points distributed over the face region. Those reflection features lie inside the face region derived from the first image, for the reasons set out under F1.2.4: the depth statement is expressly that *"of the face of the person to be authenticated"* [D1-EN, para. 416], and the delimitation of that region from the detected face and the pre-defined key points is supplied by the document itself [D1-EN, para. 472; para. 400].

67. Feature F1.3.1 is therefore disclosed in D1.

11. Feature F1.3.2

> *"wherein the detected face is characterized as 3D object if the depth level deviates from a pre-determined or pre-defined depth level of plane objects;"*

68. The reference against which D1 measures the depth statement is the quasi-planar attack instrument, and the discriminating criterion is the deviation of the measured relief from it: a real face shows a large depth difference between eyes and nose, whereas for the mask *"The coordinate depth gap is very small"* [D1-EN, para. 416]. Where the measured relief exceeds that of the quasi-planar object, the face is treated as spatially structured:

"combining the depth information can further determine whether the face of the person to be authenticated belongs to a living body" [D1-EN, para. 416]. The planar reference is named expressly, display screens and photographs being *"usually flat"* and lacking *"the three-dimensional characteristics of a human face"* [D1-EN, para. 438].

69. That the reference is fixed before the evaluation follows from the nature of the thresholded decision: a distinction between a large depth difference and a very small depth gap can be drawn only against a criterion laid down beforehand. D1 works with predetermined thresholds wherever it evaluates measured quantities, for instance the *"predetermined parameter Threshold"* for the material parameter [D1-EN, para. 414] and the *"preset similarity threshold"* for the face comparison [D1-EN, para. 367].

70. Feature F1.3.2 is therefore disclosed in D1.

12. Feature F1.4

> *"d) at least one authentication step (122), wherein the authentication step (122) comprises authenticating the detected face by using at least one authentication unit if in step b) (116) the detected face is characterized as skin and in step c) (120) the detected face is characterized as 3D object."*

71. The cumulative linkage of the material criterion and the depth criterion is stated in terms, together with the reason why the conjunction is necessary. The material criterion alone is insufficient because a skin-imitating mask can satisfy it, so that the depth criterion must be satisfied in addition:

> *"Since the attacker can use a mask made of imitation human skin to carry out the attack, even if the texture information of the person to be authenticated conforms to the distribution law of human skin texture, it may not be possible to determine that the face of the person to be authenticated is a living body, so it can be combined The depth information judges whether the person's face is a living body."*
>
> [D1-EN, para. 416]

72. Conversely, non-conformity of the material statement leads immediately to rejection, the face *"does not belong to a living body, and it is judged as a mask attack"* [D1-EN, para. 416]. Both partial results must therefore be positive, which is the logic of "skin AND 3D object". D1 confirms that architecture generally for two independently obtained liveness criteria: *"if both the light living body verification result and the action living body verification result indicate that the face of the person to be authenticated belongs to a living body, it is determined that the person to be authenticated passes the living body verification. If the result of the light living body verification result and the action living body verification result are If any one indicates that the face of the person to be authenticated does not belong to a living body, it is determined that the person to be*

authenticated has not passed the living body verification." [D1-EN, para. 454]; the same architecture is shown in step S830 of Fig. 8 of D1.

73. The authentication follows on the positive liveness result: *"At least determining whether the identity of the person to be authenticated is legal according to the information authentication result and the living body test result"* [D1-EN, para. 8; para. 326], with rejection where any partial result is negative [D1-EN, para. 327; para. 347; para. 368]. The authenticating device is the identity determination module 1040: *"The identity determination module 1040 is used to determine whether the identity of the person to be authenticated is legal at least according to the certificate authentication result and the living body test result."* [D1-EN, para. 502], implemented on the processor or on a server [D1-EN, para. 234; para. 530].

74. Feature F1.4 is therefore disclosed in D1.

III. Conclusion

75. D1 thus discloses all the features of claim 1. Therefore, claim 1 is not novel over D1. The same applies to claims 11 to 15 to the extent that they refer directly to claim 1.

G. Lack of inventive step over D1 (CN 108573203 B) in combination with D2 (WO 2020/187719 A1)

76. As demonstrated in the previous section, D1 discloses features F1.2.1, F1.2.4 and F1.3.1 at least implicitly. Only as a matter of precaution, it will be demonstrated below that the features

- the capture of the second image with the same camera with which the first image was captured (F1.2.1),
- the position of the evaluated reflection features inside the image region of the second image corresponding to the image region of the first image comprising the identified geometrical feature (F1.2.4 and F1.3.1), and
- the determination of the depth level from the second beam profile information of at least four of those reflection features (F1.3.1)

are also obvious in view of D2 and that the skilled person would combine these two documents to arrive at the solution presented by EP‘ 252.

77. In one possible assessment, D1 can be considered as closest prior art for the subject-matter of claim 1. It pursues the same purpose as EP’252 and achieves the same effect: the optical rejection of presentation attacks in face authentication on mobile terminals, and specifically

the rejection of 3D mask attacks for applications with elevated security requirements [D1-EN, para. 332; para. 413; para. 414] as against [EP'252, para. 1; para. 8; para. 132].

78. The three distinguishing features identified above concern, in their entirety, the measurement implementation of a liveness check which D1 itself demands at the level of principle: which recording device supplies the two facial recordings, which part of the pattern recording is evaluated, and by what evaluation the depth statement is obtained. Their technical effect is that both recordings originate from one and the same recording device, that the evaluation is confined to the object actually under test, and that the material statement and the depth statement are obtained from one and the same recording without a second sensor system, which keeps the computational outlay low.

79. Starting from D1, the objective technical problem is accordingly to provide a concrete measurement implementation of the liveness check taught there at the level of principle, which operates on a mobile terminal with low technical outlay.

80. To solve the problem stated, that skilled person would have drawn on D2.

I. The technical teaching of D2 (WO 2020/187719 A1)

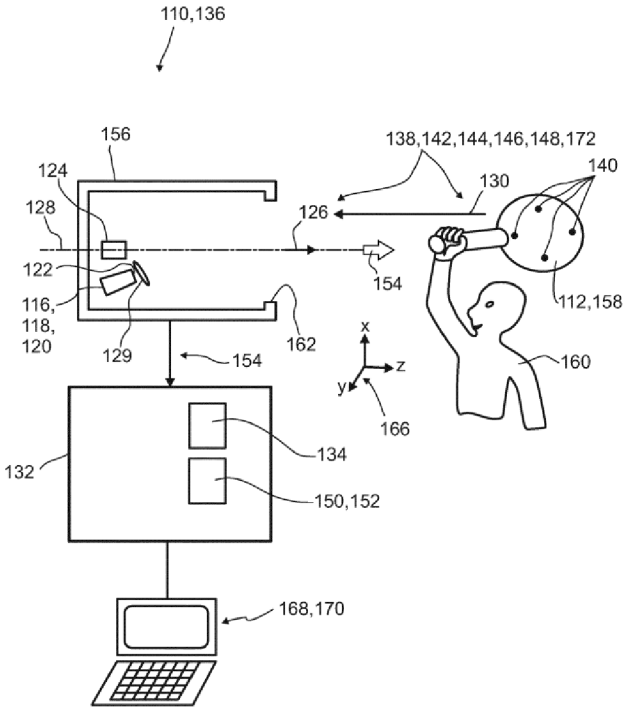
81. Document D2 was published on 24 September 2020 before the priority date of EP'252 and is therefore prior art within the meaning of Art. 54(2) EPC. The applicant of D2 is the same applicant as that of EP'252; Friedrich Schick, the first-named inventor of D2, is also among the inventors named on EP'252.

82. D2 lies in the field of optical detection technology and is concerned with the optical determination of at least one material property of an object from the beam profile of the light reflected from it, together with the simultaneous determination of the distance to that object [D2, p. 1]. Among the named fields of use are *"security technology"* and *"safety technology"* [D2, p. 1]. The problem addressed is that image filters used for beam profile analysis yield features which depend on both distance and material, so that a reliable identification of the material is frustrated [D2, p. 1, l. 35–40]. The stated object is *"to provide devices and methods which reliably may identify at least one material property of an object, preferably with a low technical effort and with low requirements in terms of technical resources and cost"* [D2, p. 2, l. 25–30].

83. The solution is a detector which records a reflection image of the light returning from the object with a sensor element comprising a matrix of optical sensors, and which evaluates the beam profiles of the reflection features contained in that image with two classes of image filter applied in parallel: a distance dependent image filter $\Phi 1$, whose output is the distance feature $\varphi 1z$, and a material dependent image filter $\Phi 2$, whose output is the material feature $\varphi 2m$. The evaluation device is configured for *"determining at least one*

distance feature φ1z by applying at least one distance dependent image filter Φ1 to the reflection image, wherein the distance dependent image filter is at least one filter selected from the group consisting of: a depth-from-photon-ratio filter; a depth-from-defocus filter; or a linear combination thereof" and for *"determining a longitudinal coordinate z and the material property m by evaluating the distance feature φ1z and the material feature φ2m"* [D2, p. 5].

FIG.1



84. The illumination source projects an illumination pattern onto the object: *"The illumination source may be configured for projecting at least one illumination pattern comprising the at least one illumination feature on at least one surface of the object."* [D2, p. 9], and expressly *"The illumination pattern may comprise a plurality of illumination features."* [D2, p. 11, l. 15–20], for instance as a point cloud [D2, p. 11]. The preferred generating means is *"at least one laser source and at least one diffractive optical element (DOE)"* [D2, p. 11], emitting in the near infrared in *"the range of 700 nm to 1100 nm"* [D2, p. 9]; the illumination source *"may be one of attached to or integrated into a mobile device such as a smartphone"* [D2, p. 12]. A reflection feature is *"a feature in an image plane generated by the object in response to illumination, for example with at least one illumination feature"* [D2, p. 8], and the beam profile is *"at least one intensity distribution of at least one of the reflection features of the reflection image, such as of a light spot on the sensor element, as a function of the pixel"* [D2, p. 14].

85. The detection of human skin is an express purpose of the detector: *"Specifically, the detector may be configured for detection of biological tissue, in particular human skin."* [D2, p. 4, l. 10–30]. The materials from which skin is to be distinguished are the typical presentation-attack materials: *"The detector may be adapted to distinguish human skin from foam, paper, wood, a display, a screen. The detector may be adapted to distinguish human skin from cloth."* [D2, p. 4, l. 10–30]. The material property may be mapped onto the classifier *"skin or non-skin"* [D2, p. 4], and the detector may keep *"at least one database comprising a list and/or table, such as a lookup list or a lookup table, of predefined and/or predetermined material properties"* [D2, p. 3]. The physical basis is the very effect on which D1 relies: *"human skin may have a reflection profile, also denoted back scattering profile, comprising parts generated by back reflection of the surface, denoted as surface reflection, and parts generated by very diffuse reflection from light penetrating the skin, denoted as diffuse part of the back reflection"* [D2, p. 12, l. 35–40], and *"These material properties may be used to distinguish skin from other materials, specifically by analyzing the back scattering profile."* [D2, p. 13]. The separation is experimentally demonstrated: *"The spot shape filter passes the hypothesis testing. The p-value computed from the F-test is 0.0076."* and *"Figure 2 shows, that this material feature separates all skin samples from the non-skin samples."* [D2, p. 126].

86. The distance determination operates on the same reflection features. The depth-from-photon-ratio filter evaluates the combined signal Q formed from two different areas A1 and A2 of the beam profile, the first area containing essentially edge information and the second essentially center information [D2, p. 16; p. 17], and yields the longitudinal coordinate from a predetermined relationship; for further detail the document refers to *"WO 2018/091640, WO 2018/091649 A1 and WO 2018/091638 A2"* [D2, p. 19]. Where a point cloud is projected, *"a plurality of illuminated regions is generated on the matrix of optical sensors"* [D2, p. 14], and a longitudinal coordinate is determined for each of the light points [D2, p. 43]. The evaluation of the reflection image is expressly bound to a region of interest: *"Specifically, the evaluation of the reflection image comprises selecting the region of interest in the reflection image. The region of interest may be determined manually by a user or may be determined automatically, such as by recognizing an object within an image generated by the sensor element."* [D2, p. 14]. Finally, D2 names the use case of face authentication itself: *"If the pattern is scarce, a single image can be used for detection of biological tissue and face identification simultaneously."* [D2, p. 11, l. 35–40], and lists *"a security application; a surveillance application; a safety application"* among the uses [D2, p. 46].

87. The two teachings meet at every point that matters for the present combination. They operate in the same technical field, namely the optical evaluation of a pattern projected

onto an object for the purpose of characterizing its surface, and they use the same architecture: one pattern-projecting illumination source, one matrix-based camera on the same side of the device, and one evaluation device that performs the assessment. The illumination source of D2 is the structured light source of D1 [D2, p. 9] as against [D1-EN, para. 209]; the sensor element with the matrix of optical sensors is the image acquisition device [D2, p. 5] as against [D1-EN, para. 301]; the evaluation device is the processor [D2, p. 31] as against [D1-EN, para. 297]. Both teachings are directed to the same deployment environment, namely the mobile device or smartphone [D2, p. 12] as against [D1-EN, para. 332; para. 433]. Both rely on the same physical criterion for the discrimination of skin, namely the scattering of light inside the material, which D1 calls the degree of subsurface scattering [D1-EN, para. 414] and D2 calls the diffuse part of the back reflection from light penetrating the skin [D2, p. 12, l. 35-40]. Both are directed against the same attack materials, namely displays, screens, paper and mask materials [D2, p. 4] as against [D1-EN, para. 414; para. 438]. And the architecture from which D1 starts is part of the technical environment which D2 expressly takes as its own point of departure: it acknowledges as known both a binocular structured-light system reconstructing a three-dimensional image [D2, p. 2, l. 5–10] and *"systems and methods for determining a depth map and a reflectivity map from a structured light image"* [D2, p. 2, l. 15–20], as well as a device for skin detection which *"comprises an illumination unit configured to project a predetermined illumination pattern onto a scene, an imaging unit configured to acquire an image of the scene, and an evaluation unit configured to evaluate the acquired image by analyzing the imaged illumination pattern as reproduced in the image and to detect skin areas within the image and distinguish them from non-skin areas within the image based on said analysis"* [D2, p. 1, l. 25–35].

88. On that basis the obviousness of the subject-matter of claim 1 is set out below.

II. Obviousness of the subject-matter of claim 1

1. Feature F1.2.1

> *"wherein the skin detection step (116) comprises projecting at least one illumination pattern comprising a plurality of illumination features on the scene by using at least one illumination unit (118) and determining at least one second image using the at least one camera (112),"*

89. D2 projects the illumination pattern by means of an illumination source which is *"configured for projecting at least one illumination pattern comprising the at least one illumination feature on at least one surface of the object"* [D2, p. 9], projecting being defined as *"providing the at least one illumination pattern for illuminating the at least one object"* [D2, p. 11, l. 35–40]. That the pattern comprises a plurality of illumination features is stated expressly: *"The illumination pattern may comprise a plurality of illumination*

features." [D2, p. 11, l. 15–20], and *"For increasing reliability, the illumination pattern may comprise several illumination features such as several points."* [D2, p. 11, l. 35–40]; the illumination source may *"generate and/or [to] project a cloud of points"* [D2, p. 11].

90. The second image is the reflection image recorded by the sensor element [D2, p. 5; p. 8]; in the case of a point pattern *"the reflection image may comprise points as reflection features"* [D2, p. 74]. Decisively for the feature at issue, that recording is made with one and the same recording device as serves the identification of the face. The base embodiment of D2 comprises exactly one sensor element, which may itself be embodied as a camera: *"the detector 110 specifically may be embodied as a camera 136 and/or may be part of a camera 136"* [D2, p. 126]; and the document expressly contemplates that a single image of that one sensor serves both purposes at once: *"If the pattern is scarce, a single image can be used for detection of biological tissue and face identification simultaneously."* [D2, p. 11, l. 35–40]. Where images are acquired in sequence, they come from that same sensor, the camera being *"configured for acquiring a plurality of images, such as a sequence of images"* [D2, p. 47], and the detector being able to operate without the pattern projector by using *"radiation already present in the scene such as from at least one ambient light source"* [D2, p. 13].

91. Feature F1.2.1 is therefore disclosed in D2.

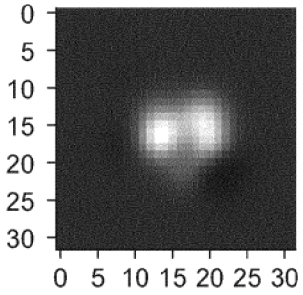
2. Feature F1.2.4

> *"wherein the skin detection step comprises determining a first beam profile information of at least one of the reflection features located inside an image region of the second image corresponding to an image region of the first image comprising the identified geometrical feature by analysis of its beam profile and determining at least one material property of the reflection feature from the first beam profile information by using the processing unit (114),"*

92. D2 determines the material feature by applying a material dependent image filter to the reflection image: *"The evaluation device is configured for determining at least one material feature φ2m by applying at least one material dependent image filter Φ2 to the reflection image. [...] The material feature may be or may comprise at least one information about the at least one material property of the object."* [D2, p. 24]. The filter operates on the beam profile, the image filter being *"at least one mathematical operation applied to the beam profile and/or to the at least one specific region of the beam profile"* [D2, p. 14], which is the analysis of the beam profile within the meaning of [EP'252, para. 105]; the material feature φ2m is beam profile information within the meaning of [EP'252, para. 61], which expressly names a material feature. The material property is then obtained from it: *"The material property m and/or the longitudinal coordinate z may be determined by using a predetermined relationship between φ1z, φ2m and z, m."* [D2, p. 30], the

definition of material property being word for word that of EP'252 [D2, p. 3] as against [EP'252, para. 64]. The evaluation is performed by the evaluation device, that is, by *"an arbitrary device adapted to perform the named operations, preferably by using at least one data processing device and, more preferably, by using at least one processor and/or at least one application-specific integrated circuit"* [D2, p. 31].

FIG.3



93. The binding of that evaluation to the image region occupied by the recognized object is a mandatory part of the evaluation taught by D2: *"Specifically, the evaluation of the reflection image comprises selecting the region of interest in the reflection image. The region of interest may be determined manually by a user or may be determined automatically, such as by recognizing an object within an image generated by the sensor element."* [D2, p. 14]; the evaluation device is accordingly adapted *"to perform a filtering method, for example, a blob-analysis and/or an edge filter and/or object recognition method"* [D2, p. 14]. The object so recognized may be a human, a body or a part of a body [D2, p. 12], and D2 names the case in which it is a face which is identified in the same image [D2, p. 11, l. 35–40]. The evaluation of the beam profiles is thus carried out on the reflection features lying inside the region that the object recognition has delimited in the image.

94. Feature F1.2.4 is therefore disclosed in D2.

3. Feature F1.3.1

> *"wherein the 3D detection step (120) comprises determining a second beam profile information of at least four of the reflection features located inside the image region of the second image corresponding to the image region of the first image comprising the identified geometrical feature by analysis of their beam profiles and determining at least one depth level from the second beam profile information of said reflection features by using the processing unit (114),"*

95. The determination of depth information from the beam profiles of the reflection features is the core of D2. The distance dependent image filter is *"a depth-from-photon-ratio filter; a depth-from-defocus filter; or a linear combination thereof"* [D2, p. 5], and the depth-from-

photon-ratio filter evaluates the combined signal Q formed from two areas of the beam profile, *"wherein x and y are transversal coordinates, A1 and A2 are different areas of at least one beam profile of the light beam propagating from the object to the detector at the sensor position, and E(x,y,zo) denotes the beam profile given at the object distance zo"* [D2, p. 16], the first area comprising essentially edge information and the second essentially center information of the beam profile [D2, p. 17]. That is precisely the quotient Q which EP'252 describes as the second beam profile information [EP'252, para. 104; para. 108; para. 116–117], and both documents refer to the same three source documents for the technique [D2, p. 19] as against [EP'252, para. 106]. From the distance feature so obtained the evaluation device determines the longitudinal coordinate z [D2, p. 5]. The intensity distribution of the individual spot which is evaluated for that purpose is the beam profile shown in Fig. 3 of D2, reproduced above.

96. The evaluation is not confined to a single spot. Where a point cloud is projected, *"a plurality of illuminated regions is generated on the matrix of optical sensors, for example the CMOS detector"* [D2, p. 14], and a longitudinal coordinate is determined for each of those points: *"The scanning system may be adapted to determine at least one longitudinal coordinate for each of the light points as described above and in more detail below."* [D2, p. 43]. The resulting set of points is processed into a surface description of the object: a surface is spanned by the measured points [D2, p. 27], and *"The mobile phone application may transform the set of points into a 3D model by connecting adjacent points with planar surfaces."* [D2, p. 41]. The number of reflection features evaluated in this way over the object region therefore exceeds four. Their position inside the region delimited by the object recognition follows from the region-of-interest selection set out under F1.2.4 [D2, p. 14].

97. Feature F1.3.1 is therefore disclosed in D2.

4. Motivation of the skilled person

98. The skilled person defined above, starting from D1 and faced with the objective technical problem of providing a concrete measurement implementation of the liveness check taught there at the level of principle, would have drawn on D2.

99. D1 itself directs the skilled person to the available body of optical liveness detection methods. It describes the structured-light variant as a compact option based on special hardware for applications with elevated security requirements [D1-EN, para. 413] and leaves its measurement implementation open, stating in terms that the liveness step may be realized by whatever methods the art offers: *"Step S230 can be implemented by using any existing or possible future living body detection method in the future, which is not limited in the present invention."* [D1-EN, para. 325]. In the same spirit it treats the delimitation of

facial regions as drawn from the existing stock of the art: *"The extraction of the skin area image can be realized based on the existing face detection and face key point location algorithms."* [D1-EN, para. 400]. A skilled person implementing that teaching is thus expressly referred to the published measurement solutions of the field.

100. Among those solutions, D2 addresses the very task that D1 leaves at the level of principle. D1 defines its material criterion as the degree of subsurface scattering on the face and evaluates it through the image gradient and the degree of diffusion of the projected spots [D1-EN, para. 414]. D2 makes the detection of human skin an express purpose of its detector, bases it on the same physical effect, namely the diffuse component generated by light penetrating the skin [D2, p. 12, l. 35–40; p. 13], directs it against the same attack materials, namely displays, screens, paper, wood, foam and cloth [D2, p. 4], and supplies the worked-out measurement route for it, namely the material dependent image filter applied to the beam profile of the reflection features together with the comparison against predetermined material properties held in a lookup table [D2, p. 24; p. 30; p. 3]. It further demonstrates that the route works: *"Figure 2 shows, that this material feature separates all skin samples from the non-skin samples."* [D2, p. 126]. The skilled person looking for the measurement implementation of the material criterion of D1 therefore finds it in D2, worked out for the same criterion, the same materials and the same physical effect.

101. The same applies to the depth statement. D1 requires, in addition to the material criterion, a statement about the relief of the face, and it obtains that statement from the very recording that carries the structured-light pattern [D1-EN, para. 416; para. 417]. D2 obtains the longitudinal coordinate from the beam profiles of the reflection features of that same pattern image, by the photon ratio of two areas of the beam profile, and does so for each of the projected light points [D2, p. 5; p. 16; p. 17; p. 43]. The skilled person thus obtains from D2 both of the statements that D1 requires from one and the same recording, which is exactly the architecture that D1 itself describes [D1-EN, para. 417]; the joint determination of the two quantities from a single reflection image is the declared object of D2 [D2, p. 5].

102. The adoption promised the skilled person the improvement that D1 leaves open. D2 states its own object as the reliable identification of the material property of an object *"preferably with a low technical effort and with low requirements in terms of technical resources and cost"* [D2, p. 2, l. 25–30], and it establishes the distance independently of luminance, object size and the material and reflective properties of the object [D2, p. 16]. For an implementation on a mobile terminal, which is the deployment environment of D1 [D1-EN, para. 332; para. 433], those are exactly the properties the skilled person is looking for; and D2 expressly contemplates that environment, its illumination source being *"one of attached to or integrated into a mobile device such as a smartphone"* [D2, p. 12] and its detector being integrable into *"a mobile phone incorporating a display device, a data processing*

device, the optical sensor, optionally the sensor optics, and the evaluation device, for the functionality of a 3D camera" [D2, p. 50].

103. The two teachings fit together without adaptation going beyond the skilled person's craft. Both operate with a pattern of several spots projected onto the object, both record it with a matrix-based camera on the user-facing side of a mobile device, and both perform the evaluation on a processor of that device [D2, p. 9; p. 5; p. 31] as against [D1-EN, para. 209; para. 301; para. 297; para. 433]. D2 expressly names the application in which its detector serves a face, a single image being used *"for detection of biological tissue and face identification simultaneously"* [D2, p. 11, l. 35–40], and lists security applications among its uses [D2, p. 46]; that is the very use case of D1. The architecture from which D1 proceeds is moreover part of the technical environment in which D2 itself is situated, since D2 acknowledges as known both a binocular structured-light system and the determination of a depth map from a structured light image [D2, p. 2, l. 5–10; p. 2, l. 15–20]. The transfer of the evaluation of D2 into the structured-light branch of D1 therefore called for no more than the application of the disclosed image filters to the spot pattern that D1 already projects and records.

104. The combination yields each of the three features at-issue directly. As to F1.2.1, D2 supplies the pattern with a plurality of illumination features and a single sensor element which serves the detection of biological tissue and the identification of the face from one and the same image [D2, p. 11, l. 15–20; p. 11, l. 35–40; p. 126], so that the skilled person implementing the liveness check of D1 on the user-facing camera of the mobile terminal [D1-EN, para. 433] takes both recordings with that one camera. As to the region binding in F1.2.4 and F1.3.1, D2 makes the selection of the region of interest by recognition of the object in the image a mandatory part of the evaluation [D2, p. 14], while D1 supplies the face detection on the plain image and the key-point-based delimitation of the facial regions [D1-EN, para. 472; para. 400]; the skilled person combining the two evaluates the beam profiles of those reflection features which lie inside the face region so determined. As to the depth level in F1.3.1, D2 determines the longitudinal coordinate for each light point of the projected cloud from the beam profile of that point and assembles the resulting points into a surface description [D2, p. 43; p. 41], so that the relief statement which D1 requires, namely the comparison of the coordinate depths at the eyes and at the nose against the quasi-planar mask [D1-EN, para. 416], is obtained from the beam profile information of more than four reflection features within the face region.

105. The remaining features of claim 1 are taken unchanged from D1, as set out above: the method framework and its purpose, the face detection with the identification of pre-defined geometrical facial features, the skin detection step, the reflection features with their beam profiles, the characterization of the detected face as skin against a predetermined reference,

the 3D detection step with the characterization against the quasi-planar reference, and the cumulative authentication decision. In particular, the linkage of the material statement and the depth statement into a single condition is already provided by D1 together with the reason for it [D1-EN, para. 416], and the derivation of both statements from one and the same recording is provided by both documents alike [D1-EN, para. 417] and [D2, p. 5].

106. The combination of the two teachings thus yields a method having all the features of claim 1, and it does so without any measure exceeding the routine work of the skilled person.

III. Conclusion

107. The combination of D1 with D2 therefore leads the skilled person in an obvious manner to the subject-matter having all the features of claim 1. This applies irrespective of whether features F1.2.1, F1.2.4 and F1.3.1 are already directly and unambiguously disclosed in D1; in any event they were obvious for the reasons set out.

108. The subject-matter of claim 1 accordingly does not involve an inventive step. The same applies to claims 11 to 15 to the extent that they refer directly to claim 1. The ground for opposition under Art. 100(a) EPC in conjunction with Art. 52(1), 56 EPC is made out.

H. Dependent claims

109. The additional features of the dependent claims 2 to 10 do not add anything patentable to independent claim 1.

I. Claim 2

> *2. The method according to the preceding claim, wherein steps a) to d) are performed by using at least one device, wherein access of the device is secured by using face authentication, wherein the method comprises permitting access to the device if the detected face is authenticated.*

110. Claim 2 adds that steps a) to d) are performed by using at least one device, wherein access of the device is secured by using face authentication, and access is permitted if the detected face is authenticated.

111. This does not add anything patentable. Securing access to, and unlocking, a device by biometric – in particular facial – authentication belonged to the common general knowledge of the skilled person well before the priority date: camera-based face-unlock functionality and fingerprint-unlock functionality had by then been in mass-market use on smartphones for several years. The patent itself confirms this: paragraph [0002] states that biometric features *"combine personal identity with an unlock process"* as an established alternative to passphrases and PIN codes, presenting this as known background rather than as part of the claimed contribution. Applying the face/liveness authentication method

already known from D1 to this well-known, notorious use – securing access to the very device performing the authentication – requires nothing beyond the skilled person's routine application of a known authentication result to its most obvious purpose, and yields no further technical effect.

112. Claim 2 therefore does not involve an inventive step (Art. 56 EPC).

II. Claim 3

> *3. The method according to the preceding claim, wherein the method comprises at least one enrollment step, wherein in the enrollment step a user of the device is enrolled, wherein at least one 2D image of the user is stored in at least one database, wherein the method comprises identifying the user by comparing the 2D image of the user with the first image.*

113. Claim 3 adds that the method comprises at least one enrollment step, in which a user of the device is enrolled by storing at least one 2D image of the user in at least one database, and that the method comprises identifying the user by comparing that 2D image with the first image.

114. This is disclosed in D1. In paragraphs 317 to 320, D1 discloses storing a 2D face image of the person to be authenticated – the *"credential face"* – in a *"certified credential information database,"* held locally or on a server. In paragraph [0014], D1 discloses comparing that stored credential face with the person's live-captured face image, in what it calls the *"face consistency judgment,"* in order to identify the person. D1 therefore discloses storing a 2D image of the user in a database and identifying the user by comparison with the first image.

115. The subject matter of claim 3 is therefore also not novel over D1.

III. Claim 4

> *4. The method according to any one of the preceding claims, wherein in the skin detection step at least one parametrized skin classification model is used, wherein the parametrized skin classification model is configured for classifying skin and other materials by using the second image as an input.*

116. Claim 4 adds that in the skin detection step at least one parametrized skin classification model is used, configured for classifying skin and other materials by using the second image as an input.

117. This is disclosed in D1. In paragraph 27, D1 discloses training a classifier on a positive sample image, extracted from a real person, and a negative sample image, extracted from a fake person, to obtain a *"skin elasticity classifier."* In paragraph 26, D1 discloses applying that classifier to a captured skin area image in order to obtain the living-body (skin) detection result.

118. D1 therefore discloses a parametrized skin classification model applied to image data to classify skin against other materials. Claim 4 is not novel over D1.

IV. Claim 5

> *5. The method according to the preceding claim, wherein the skin classification model is parametrized by using machine learning, wherein the property characteristic for skin is determined by applying an optimization algorithm in terms of at least one optimization target on the skin classification model.*

119. Claim 5 adds that the skin classification model is parametrized by using machine learning, wherein the property characteristic for skin is determined by applying an optimization algorithm in terms of at least one optimization target on the skin classification model.

120. This is disclosed in D1. In paragraph 411, D1 discloses that *"a statistical learning method such as deep learning or SVM can be used to train the classifier model to obtain a skin elasticity classifier"* from positive and negative sample images. Training a classifier by deep learning or a support vector machine necessarily optimizes the model against a classification-accuracy objective.

121. D1 therefore discloses parametrizing the skin classification model by machine learning, through application of an optimization algorithm on an optimization target. Claim 5 is not novel over D1.

V. Claim 6

> *6. The method according to any one of the two preceding claims, wherein the skin detection step comprises using at least one 2D face and facial landmark detection algorithm configured for providing at least two locations of characteristic points of a human face, wherein in the skin detection step (116) at least one region specific parametrized skin classification model is used.*

122. Claim 6 adds that the skin detection step comprises using at least one 2D face and facial landmark detection algorithm configured for providing at least two locations of characteristic points of a human face, wherein a region-specific parametrized skin classification model is used.

123. This is disclosed in D1. In paragraphs 400 to 403, D1 discloses a *"face key point location"* algorithm locating facial landmarks including *"the corner of the left eye, the tip of the nose, and the corner of the left lip"* – more than the claimed two characteristic points – implemented, per paragraph 401, by a trained deep neural network. Paragraph 400 further discloses that these landmarks are used to confine the skin classification to specific face regions, namely the image fragments located in the chin, cheekbones, and cheeks.

124. D1 therefore discloses a facial landmark detection algorithm locating at least two characteristic points and a region-specific skin classification based on those landmarks. Claim 6 is not novel over D1.

VI. Claim 7

> *7. The method according to any one of the preceding claims, wherein the illumination pattern comprises a periodic grid of laser spots.*

125. Claim 7 adds that the illumination pattern comprises a periodic grid of laser spots.

126. This is disclosed in D2. D2 discloses an illumination source comprising a laser source together with a diffractive optical element (DOE), configured as a *"point projector ... adapted to project at least one point pattern,"* the pattern being expressly described as *"regular and/or constant and/or periodic"* [D2, p. 11].

127. D2 therefore discloses a periodic grid of laser-generated spots. Claim 7 is not based on an inventive step over D1 in combination with D2.

VII. Claim 8

> *8. The method according to any one of the preceding claims, wherein the illumination features have wavelengths in a near infrared (NIR) regime, wherein the illumination features have wavelengths of 940 nm.*

128. Claim 8 adds that the illumination features have wavelengths in the near infrared (NIR) regime, specifically 940 nm.

129. This is disclosed in D2, alternatively common general knowledge. D2 discloses illuminating and sensing in the near-infrared band and identifies *"700 nm to 1100 nm"* as the preferred range for silicon-photodiode-based detection [D2, p. 7]. That range squarely encompasses the claimed 940 nm. In any event, 940 nm is the standard NIR wavelength used in eye-safe consumer 3D-sensing and face-recognition modules, and its selection is accordingly a matter of common general knowledge that requires no inventive skill. The additional feature of claim 8 does not add anything patentable.

VIII. Claim 9

> *9. The method according to any one of the preceding claims, wherein a plurality of second images is determined, wherein the reflection features of the plurality of second images are used for skin detection in step b) (116) and/or for 3D detection in step c) (120).*

130. Claim 9 adds that a plurality of second images is determined, wherein the reflection features of the plurality of second images are used for skin detection in step b) and/or for 3D detection in step c).

131. This is disclosed in D1. Paragraph 31, mirrored in claim 34, discloses acquiring *"multiple illumination images"* of the face and evaluating the light reflection characteristics across those images to obtain the living-body (skin) verification result. Paragraphs 209 and 415 to 416 disclose the corresponding multi-image, structured-light/binocular acquisition used for the depth (3D) determination.

132. D1 therefore discloses using a plurality of images for the skin detection and/or 3D detection steps. Claim 9 is not novel over D1.

IX. Claim 10

> *10. The method according to any one of the preceding claims, wherein the camera (112) is or comprises at least one near infrared camera.*

133. Claim 10 adds that the camera is or comprises at least one near infrared camera.

134. This is disclosed in D2. D2 discloses an optical sensor that is *"sensitive in the infrared spectral range, preferably in the range of 700 nm to 3.0 micrometers,"* specifically in the near-infrared range compatible with silicon photodiodes [D2, p. 7].

135. D2 therefore discloses a near-infrared camera within the meaning of claim 10. Claim 10 is not based on an inventive step over D1 in combination with D2.

I. Independent claims 11 to 15

136. Claims 11 to 15 are directed to a computer program, a computer-readable storage medium, a non-transient computer-readable medium, and a mobile device, respectively, that are all configured for performing steps a) to d) of the method according to any one of claims 1 to 10. The subject matter of each of claims 11 to 15 is thus not novel and not based on an inventive step for the reasons set out in connection with claims 1 to 10.

Dr. Tobias Stammberger

Professional Representative

Exhibits:

D1: CN 108573203 B, published on 26 January 2021,

D1-EN: English translation of document D1 (taken from the prosecution file of the patent's divisional EP 4 546 296; the text in the drawings was machine translated)

D2: WO 2020/187719 A1, published on 24 September 2020.

SP1: Excerpt from the UPC statement of claim (Local Division Mannheim)

SP2: Letter of service of the Unified Patent Court, Local Division Mannheim

SP3: Feature Analysis of claim 1