Vetenskapsrådet

Application

2015-03-31

2015-04793	Bigun, Josef	NT-14

Information about applicant

Name: Josef Bigun

Doctorial degree: 1988-05-06

Birthdate: 19610108

Academic title: Professor

Gender: Male

Employer: Högskolan i Halmstad

Administrating organisation: Högskolan i Halmstad

Project site: Halmstad Embedded and Intelligent Systems research (EIS)

Information about application

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Funds applied for

Year:	2016	2017	2018	2019
Amount:	1,789,540	1,842,067	1,907,888	1,974,562

Participants

Name: Fernando Alonso-Fernandez

Doctorial degree: 2008-10-01

Birthdate: 19780531

Academic title: Doktor

Gender: Male

Employer: Högskolan i Halmstad

Descriptive data

Project info

Project title (Swedish)*

Kompakt beskrivning av bilder genom deras partikel och våg natur

Project title (English)*

Sparse description of images by their particle and wave natures

Abstract (English)*

The overall goal is to deepen understanding of image description, especially those relying on orientation to achieve more systematic content representation. If there were a small, but better understood, orientation features, much more visual intelligence could be integrated into small devices like cell phones, robots and navigators, since applications could share functions. Orientation features are important for machine vision since human vision relies on them.

Local spectra are normally used to describe the wave nature of local image patches, e.g. textures. Waves are however not localized by definition, and images contain also patches that have particle nature, characterized by being localizable, e.g. key-points in computer vision, and minutia, cores, etc, in fingprints. The project will study the two natures jointly and aims to incorporate these within the same theory, producing a common toolbox.

The project will study the implications of putting a limit on different orientations that may be present jointly in local images, Orientation Cardinality, in analogy with Shannon´s theory, defining an upper bound for wave frequencies that may jointly be present in a signal, Nyquist frequency. Sparse representations for recognition will be studied under Orientation Cardinality. The test benches will be i) identification of forensic fingerprints and ii) biometric identification by periocular regions. Additionally robotics tasks comprising object tracking by keypoints are envisaged as student projects.

Popular scientific description (Swedish)*

Det övergripande målet är att fördjupa förståelsen för bildbeskrivning, särskilt de som förlitar sig på orientering för att få mer systematisk innehållsrepresentation. Om det fanns en liten, men bättre förstådda, orientering baserade deskriptorer, kunde mycket mer visuell intelligens integreras i små enheter som mobiltelefoner, robotar och navigatörer, eftersom tillämpningarna kunde dela funktioner. Orientering deskriptorer är viktiga för maskinseende eftersom det mänskliga ögat är beroende av dem.

Lokala spektra används normalt för att beskriva våg naturen i bild delar, t.ex. texturer. Vågor är dock inte lokaliserbara per definition, och bilder innehåller även delar som har partikel natur, som kännetecknas av att dessa är lokaliserbara, t.ex. öndpunkter, hörn och korsningar i bilder, minutia, delta mönster i fingeravtryk, etc. Projektet kommer att studera dessa två naturer gemensamt i syfte att att införliva dessa inom samma teori, för att producera en gemensam verktygslåda.

Projektet kommer att studera konsekvenserna av att sätta en gräns för olika orienteringar som kan förekomma samtidgt i lokala bilder, som kallas orienterings kardinalitet. Detta är i analogi med Shannon's teori, som definierar en övre gräns för vågfrekvenser som samtidigt kan vara närvarande i en signal, Nyquist-frekvensen. Glesa representationer för igenkänning kommer att studeras under Orientering kardinalitet begreppet. De test tillämpningar projektet kommer att använda sig av är i) Identifiering av kriminaltekniska fingeravtryck och ii) biometrisk identifiering genom periokulära regioner av ansiktet. Dessutom robot uppgifter omfattande att följa objekt genom nyckelpunkter planeras som studentprojekt.

Project period

Number of project years*

4

Calculated project time*

2016-01-01 - 2019-12-31

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes*

2. Teknik > 202. Elektroteknik och elektronik > 20205. Signalbehandling

2. Teknik > 202. Elektroteknik och elektronik > 20207. Inbäddad systemteknik

2. Teknik > 202. Elektroteknik och elektronik > 20201. Robotteknik och automation

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Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

Feature extraction

Keyword 2*

Biometric identification

Keyword 3*

Image understanding

Keyword 4

Forensics

Keyword 5

Research plan

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

The project will use publicly available research data sets distributed by governments of EU-countries and USA. Basically, these are fingermark and face periocular images which are completely anonymized. The project addresses basic research issues in image analysis. Cameras will be used in robotics applications to teach machines how to navigate indoors attempting to recognize where robots are using pictures of walls, etc. In particular, no recording of people will be done. Issues that can raise ethical challenges are not foreseen.

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

Sparse description of images by their particle and wave natures

1 Motivation: community perspective

A fundamental aspect of image analysis is the availability of relevant models for description of image contents. This also includes reliable estimation of model parameters, that is, feature extraction. A feature vector is used in nearly all applications of image analysis since powerful descriptors constitute the fundament of success for countless applications, e.g. smart phones, life sciences, transportation, robotics, surveillance, human-machine interfaces and communication, or biometric identification.

Although much is still unknown about human vision, the current evidence supports that humans use directional features (neuronal processing in V1) as input for all visual signal processing, a milestone discovery, [23, 21, 39]. This generalist approach to feature extraction is however far from the current practice of machine vision. Rather, the prevalent approaches favor a cook-book approach: system designers choose many different but also similar "dishes", to be included in their feature vector. Accordingly, there are progressively many feature vectors that drive the ever popular demand for automatic visual intelligence in the society, including those which have vital consequences, such as in-car collision avoidance systems, early detection of cognitive/motor diseases, or harmful situations for children, elderly, or impaired.

This is because each feature vector is successful in some applications and less so in others. Additionally, the extracted feature vector is often the result of several heuristically designed computation modules, rather than produced by fitting a model to the data e.g. by minimization of an error. This hampers a deeper understanding of the vector since a principled judgement of the quality and the relevance of its elements becomes then difficult. Consequently, predicting and evaluating the feature vector behaviour presupposes a more principled derivation and analysis of it, which is currently lacking. A taxonomy of features as to which categories of image description problems they are most useful is thus needed to quickly create advanced vision systems.

If there were a smaller, but better understood, set of "deep" features that could be applicable to fundamental vision tasks, many more and novel applications could be integrated into thin mobile devices such as smart phones, robots and navigators. These would "see" better with time-saving and increased safety contributions. In this project, we wish to study *sparse* representations of visual signals with *orientation* and *frequency* features in focus. We will use identification of periocular face regions (englobing iris), and forensic fingerprints for evaluations because they are challenging tasks. The former would bring a tangible difference to, among others, the use of 6.8 billion mobile phones, and social networks. The periocular region refers to the vicinity of the eye (including eyelids, lashes and eyebrows), and it has shown a surprisingly high discrimination ability [37]. It has the enormous advantage of being available over a wide range of acquisition distances, even when the iris texture cannot be obtained (low resolution) or the face is partially occluded, so it is currently receiving extensive attention. On the other hand, forensic fingerprints are of interest in the investigation of most crime scenes, with research in this area being pushed by security forces worldwide.

Faster and more stable vision methods already on the low-level of feature extraction can be expected to lessen the demand of complex and time consuming modelling by machine learning methods from examples. To provide for descriptors that can be (mathematically) completed with systemacy will be aimed at. A consequence of this will be a greater standardization in vision applications with tangible benefits to embedded computers with limited computational resources, e.g. mobile phones, in cars, and remote sensors, to sub-serve multiple applications, rather than every application comes with its own different feature set, which is the current practice.

The proposal will contribute to sparse and principled feature extraction by describing image neighborhoods based on their *wave* and *particle* natures. The wave natured neighborhoods are illustrated by the examples of Fig. 1 (1A, 1B) whereas two particle natured neighborhoods are illustrated by Fig. 1 (2A, 2B). The latter are well localized (particle) and unique whereas the former are everywhere in plenty repetitions (wave).

2 Objectives

The main goal is a description of both waves (textures) and particles (keypoints) using the same theoretical and practical framework, so that the extracted features will be scalable in complexity (simple to elaborate descriptions) and in breadth (across applications). To this end, we wish to develop several tools and concepts.

Local non-linear deformations, in the first place *harmonic* coordinate transformations and the structure tensor, [7], [34], [2], will be aimed to combine with globally linear techniques, e.g. convolution [2], to achieve high levels of sparsity for both wave and particle natures of local images. The sparsity will be purposive, with *pattern recognition* determining the usefulness. This should be contrasted to the traditional sparsity, aiming at *reconstruction of images*. A higher degree of systemacy, and efficiency, when designing, computing and analyzing feature vectors for pattern recognition are the expected results. Our primary test bed will be person identification, at least in two different modalities, as detailed in the work plan.

Orientation cardinality is the upper limit of maximally different orientations that can jointly occur in compact definition sets of images, typically local neighborhoods, but also larger compact regions such as a torus. Orientation cardinality is similar to Nyquist frequency, but is poorly studied. It concerns the non-metric, angular frequency dimension(s) which is periodic, therefore always integer. Understanding orientation cardinality's role in pattern recognition is a goal of the project. It is expected that the results will enable compact description of dense orientation and frequency maps more systematically than the current practice. Extraction of such maps will be an integral part of the systemacy aimed at.

Another aimed tool is an algorithm for systematic generation of feature extraction methods. This is expected to be done by using the same computational pipeline but adding more complex filters, to more layers, implementing Cartesian and curvilinear orientation measurements progressively. This will allow to assess the wave and particle natures of image neighborhoods progressively. Measurements in Cartesian coordinates of the wave nature aim to equip *regions* with unique "identities". An analogous approach but describing the particle nature in concentric tori around a *point* in systematically changing curvilinear coordinates is expected to extract evidence for the uniqueness of the point, as well as recognize it among other points (tracking keypoints). Likewise, such measurements aim to equip *points* with unique "identities".

The connection with the front end of the human visual system (strongly directional by nature) holds promise for interesting insights into the mammalian visual processing and can give rise to coding schemes which can be perceptually phrased at the same time as they can be phrased mathematically in a principled manner.

3 State of the art

The concept of 'efficient' image representation has traditionally been based on Hilbert space theory and on assuming existence of an upper bound for frequencies in metric dimensions (by Nyquist frequency) to represent image contents. With few exceptions, this has favored extensions of 1D basis functions to 2D and higher dimensions, e.g. sinusoids (Fourier basis), and piecewise polynomials (wavelets, and splines), [30, 41, 42, 14] to represent images via synthesis of known basis functions. What is left out (noise) in the approximation is determined by absolute frequencies, frequency cardinality. Notable successes are image compression applications in digital communication and storage. In this representation, the principal modeling "efforts" of the content is vested in reconstructing image spectra *sparsely* with metric dimensions in the focus. Synthesis coefficients as features are therefore rich quantifiers of the wave nature. In [17] however, the angular dimension, which is non-metric, has been taken into consideration, though with absolute frequency dimension still taking the precedence.

However, such minimalistic way to reconstruct an image does not mean that it is the most suitable for recognizing regions or objects in the image. If that would be the case, image

understanding applications would not need to extract features as they would be available in compression coefficients. But the vast majority of machine vision is still done on the original image, ignoring the reconstruction coefficients, e.g. of JPEG, including JPEG 2000, and MPEG, including MPEG4.

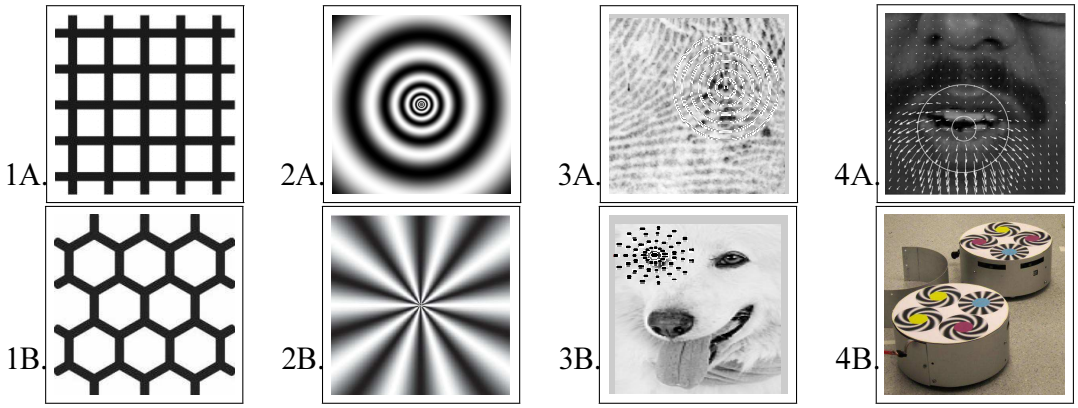

Figure 1: *1A-B* Local images contain 2 and 3 directions, respectively, (unlocalized/wave). *2A-B* Rotation and scale invariant iso-curves (localized/particle). *3A-B* Fingerprint minutia and eye recognition by orientation description of their neighborhoods. *4A* Speech and Speaker recognition by lip-motion orientation and audio *4B* Log-spiral codes to locate and identify multiple moving robots simultaneously.

Sampling local spectra polarly is equivalent to project the image to a fixed set of filters, such as Gabor filters [20, 16, 26, 22], quantifying the wave properties. However, when increased accuracy on orientation and frequency is needed, the filter set and the projections must be redone. Nonetheless, a systematic analysis of filter responses to sparsify their representation of orientation and frequency, and to complement (not to discard) the achieved projections, an aim of the project, is desirable.

The scale space theory [11, 27, 28], which has emerged from machine vision community, analyzes the image content with limited scale assumption. The original image (the finest scale) undergoes a diffusion process, governed by the heat equation, producing blurred versions of the original. The disappearance of "objects" in the visual signal defines the effective scale as well as the spatial coordinates of (disappearing) objects. There is then an object size below which the scale space discretization cannot detect the object, the scale cardinality. In practice scale cardinality and frequency cardinality are two similar assumptions in that they both attempt to describe physical properties that are related to the metric size of objects. In the project, "texture", [24] will be seen as an embodiment of wave type objects whereas "keypoint" [38, 28] will be an example of particle type objects.

Scale space based description has been complemented by orientation description of image content, by means of orientation or gradient direction histograms [29, 13] at scale space keypoints, e.g. orientation radiograms, SIFT, SURF, and LBP [32, 29, 5, 35]. An assumption of these methods is that the local image has a "main axis" according to which it can be aligned before its histogram is extracted, to achieve rotation invariance, a desirable property for many machine vision applications. Another assumption is that two different patterns have also different direction histograms. However, there exist innumerably different patterns which are well localized but violate these basic assumptions, suggesting the need for a deeper systemacy concerning completition of the description power in the histograms.

By way of example, the circular and radial members of the log-spiral family, Fig. 1 (2A-B), do not differ regarding their histograms of orientations to begin with. They have not a unique axis of direction. Nor, they have a specific scale in which they vanish, since they remain equally visible in every scale. Even if detected, rotation alignment of them will not be meaningful. By contrast, humans can reliably detect and differentiate all members of log-spiral family, not just those shown.

4 Project work plan

The project will be implemented in 48 months.

Theoretically, both wave Fig. 1 (1A-1B) and particle Fig. 1 (2A-B, and 4B), natures of visual objects will be studied, with sparsity of orientation representation to be given the primary importance. The shown textures have orientation cardinality two and three respectively, whereas the keypoints have orientation cardinality one (locally), which is most obvious when iso-curves are studied in spectra of log-polar coordinates, [7].

In practice, two applications will be used as a test bed, each under supervision of a senior researcher having long experience from the application as well as theory, together with a PhD student. These are i) identification of fingermarks collected at crime scenes and ii) identification by periocular data including iris. The choice is motivated by that there is an extensive familiarity with applications of biometrics in our research group. This helps to predict and deploy resources for known solutions keeping the research resources focused on fundamental issues.

Additionally, master student projects in robotics will contribute to validation of our methods in focused tasks. Robotics is a very wide subject including many challenging image analysis tasks, but not only. Feature tracking is an established sub-task by which tracking of objects is modeled and executed using cameras. However, this is still a research subject, which motivates this choice.

Months 1-12:

Description of orientation contents by a series of complex moments of the spectrum, sampling the spectrum sparsely under a given orientation cardinality n, will be the starting point. Angular moments computed in the spatial domain would not require more than $2n$ real filters to deliver the orientation constellations of an image, according to preliminary results, [34]. The procedure resembles description by moments, but it is tensor fields that are described. This is though not to be confused with the steerable filters, [19], applied directly to gray images. The theory of wave and particle natures can both share common elements, although they will have differing elements too. Using different coordinate transformations before moment computations is expected to model particle nature with the same framework as wave nature description, as preliminary results indicate. Nonetheless, there can be other ways of reconciling both natures into a common theoretical frame.

Background knowledge is important to establish for evaluations. At least two well published feature vectors will initially be studied, [29], [35], w.r.t. their abilities to discern wave and particle natured visual objects systematically, i.e. discriminate a texture from another texture, and a unique keypoint from a different keypoint.

Ground truths for locations of valuable keypoints in forensic fingerprints, fingermarks, are already available, [33]. However, to test usefulness of features in operational scenarios, an automatic minutia extraction process which is formally different than minutia description, should be developed for good quality mates of fingermarks. Thousands of such good quality images are normally searched for a single fingermark (which is a very bad quality image!). The procedure of extraction and description must be automatic for tenprints, and semi-automatic for the query fingermark, resulting in a shortlist verified by a human expert. Here we expect that particle nature characteristics of minutiae will be useful to locate them generically first (in tenprints). For the generic step, the particle nature will be described in terms of orientation models in concentric circles, Fig. 1 (3A), in fine scales so that this can be used to automatically extract minutia locations.

We will also aim at enabling *direct* automatic detection of periocular regions (iris/eye regions). Prevalent systems rely on detecting the face first, e.g. [43], which means that currently the detection inherits all errors of face recognition. We think that periocular regions can be detected and localized precisely without being indexed to the recognition of faces. This will benefit to mobile machines (e.g. smartphones, robots) or zoomable surveillance cameras. These can then focus efficiently into periocular regions. The particle nature of eye centers will be most evident if orientation is described in curvilinear coordinates. Preliminary studies with the circular member of the log-spiral family, Fig. 1

(2A), have already given promising results in this direction [2]. Completion, using other particle-like features of the generalized structure tensor, will be sought for higher pattern recognition accuracy. Although it will not be pursued here, the understanding about the particle nature of eye regions can also enable similar studies with other facial regions (nose or mouth), or to extend our findings to other animal species [10].

Months 13-24:
Images have huge diversity in their content and usage, demanding features be invariant to certain geometric transformations, comprising rotation and scaling, in the sense that images must not be transformed geometrically (e.g. rotated and/or scaled) to compute the corresponding features after the transformation. Since the matching step in diverse applications demand features to be resilient to common geometric transformations, the latter should be possible to do (computationally) cheaply without actually performing the transformations and then recomputing the features.

Our preliminary studies suggest feasibility of orientation invariance of compact measures describing orientations in tori, [34]. We need to extend this such that both scale invariance for particles and automatic scale selection for waves can be optionally invoked. The former will be studied by sampling of the (metric) radial dimension in geometric progression such that a focusing/defocusing operation becomes a translation in the log-polar sampling grid. The latter will be studied by automatic estimation of frequencies, which, interestingly seems to be deducible from orientation estimation, but in the scale space generated by the logarithm of the structure tensor.

The model parameters of a minutia extracted at fine-scales at the beginning of the project must by necessity be generic to allow to recognize (~detect) a minutia, as such. This will however not allow to recognize (~discriminate) this minutia among thousands of other minutiae. To do that, image information farther away from the minutia location will be invoked. It is expected that the image information will be possible to describe by orientation variations in larger and larger tori farther away from the minutia.

Concerning the periocular modality, eye detection invariant to in-depth rotation and scale changes is still a challenge with current technologies [31]. Periocular studies so far have used images in semi-controlled environments and constant distance relative to camera, a limitation that we will seek to overcome. Our initial studies include automatic frequency estimation, which has shown to aid eye detection considerably by allowing automatic parameter selection of invoked symmetry filters used to extract the orientation map [2]. This will be complemented by the use of different particle-like features of harmonic curve families that are expected to enable rotation and scale invariant detection and description, [40]. For example, the radial member of the log-spiral family, Fig. 1 (2B), is invariant to scale changes, and highly stable to in-depth rotations due to having multiple “legs”. We will also seek to describe the particle nature of the eye region in concentric circles around the eye center, as in Fig. 1 (3A) for fingerprints, which, we expect, will allow automatic scale (~distance) estimation. Arranging the circles in geometric progression around eyes is expected to produce observations in which scale changes will be convenient to analyze, since they reduce to translations. This will help constructing features that are more resilient to scale changes.

Months 25-36:
Theoretically, the wave nature of images comprising waves having different directions can be described by a feature vector. However, in image analysis applications it is desirable that the different waves be separated. This problem is known as source separation in signal processing. However, here we will study the problem of source separation from local signals such that global continuity is achieved in local solutions.

In practice, the wave nature of fingerprints are visually evident, especially in tenprints which are fingerprints having high quality since they are imaged at government offices such as passport units, or police stations. However, in fingermarks, which are collected at crime scenes, there can be significant complexity to orientation expression in local neighborhoods. First and foremost there can be more than one fingermark in the same location. Second, there can be other strong orientation expressions

originating from the interfering, non-relevant backgrounds, e.g. the fine regular lines composing a banknote having similar spatial frequencies as the fingermarks left on them. Accordingly, a forensic examiner can be helped if there would be automatic tools suppressing the interference continuously. Here source separation would be very useful. Our theoretical results will therefore be evaluated in this test bed.

Nearly all commercial iris recognition systems are based on texture analysis by Gabor filters [15]. The success of the periocular modality for identity recognition relies precisely on processing the surrounding skin texture and associated regions (eye-cavity, including eyelash line, etc.), currently by histograms of gradients, [29], and by histograms of iso-curve directions, [35]. However, there has been no other studies than, [2], [34], which are preliminary, on what nature of the periocular data matters to identification. We plan an in-depth analytic and practical study concerning what state-art-features can measure with periocular data as test bed. We are expecting that periocular data, having in-depth rotation and scale variations not present in fingerprints, will offer additional insight to particle and wave descriptors than the fingerprint test-bench cannot afford.

Months 37-48:
It is worth noting that forensic experts do already advanced orientation descriptions of regions around keypoints, which we think why their skills and reliability are so uncircumventible. However, only minutia/core positions and minutia/core directions information, as a list extracted by a human expert, survives to the higher automatic search stage executed by a machine. That is, a machine executes a search using the list, which is not even an image, and is a tiny fraction of the actual visual information the human vision has analyzed, to pull out candidates of tenprints best matching the queried fingermark. This is because humans currently cannot pass their visual depictions of the vicinities of keypoints to machines. Quantifying, recording and passing more of the results of human descriptions to machine vision *reliably* will be therefore at the focus in this period.

A human machine interface which will be able to turn human visual knowledge to machine representation and receive feedback/corrections on machine extracted visual knowledge will be studied in this phase. It is expected that such a system will reduce costly errors, e.g. false convictions, exemplified by the high-profile fingerprint matching error when prosecuting Madrid-bombings in 2004, which linked erroneously an innocent in USA (who had never been in Madrid) to the deed! We wish to teach some of human abilities as machine vision tools to improve the quality of decision making of forensic experts as demonstrator of that it is indeed possible and other applications can also benefit from it. This is envisaged to be done by encoding feature vectors, as well as orientation and frequency maps in color. It is planned that the period will focus on tools enabling human experts viewing, evaluating and editing orientation and frequency maps in a simple manner. Knowledge transfer from humans to machines will then be achieved by means of painting tools when humans do not agree with machine evaluations. It is worth mentioning that this is not a GUI development because the underlying actions must be done by invoking advanced feature extraction and image processing actions to be developed in the project.

At this stage, more practical evaluations will take place with periocular data comprising more realistic conditions: fixed cameras (such as in-car or laptop webcam), handheld devices (such as smartphones, with self-acquisition done with the camera as the person moves), and surveillance cameras (where the person walks by the detection equipment). This will allow the evaluation of different degrees of control during the acquisition, allowing to assess the merit of the techniques developed, both regarding detection of the periocular region and identity recognition. Contrarily to existing periocular studies, we will seek generalization to less controlled conditions, with face in arbitrary pose and scale. Successful implementation of the techniques proposed will enable the use of a vast amount of devices already in place. An overriding goal is that solutions should not be perceived as cumbersome nor intrusive, while they should be reliable and simple to interact with, enabling combination with other modalities, e.g. face and speech, [6].

5 International and national Cooperation

The applicant has been collaborating with several groups in Europe and USA, in image analysis research in general, and biometrics in particular, as well as in education. Many activities have been carried out in the framework of collaborative projects, such as BIOSECURE (an EU Excellence Centres consortium), BBFOR2 (EU Marie-Curie research school), or IC-1106 (EU COST consortium), to name but a few. The most active collaborations have been with Prof. M. Tistarelli, at University of Sassari (IT), Prof. J. Ortega-Garcia and Dr. J. Fierrez at Autonomous University of Madrid, Prof. A. Jain and A. Ross at Michigan State University (USA), Prof. R. Veldhuis at University of Twente (NL), Prof. D. Maltoni and Dr. R. Capelli at Bologna University (IT), Prof. Christoph Busch at Gjövik Uni. College and at Fraunhofer Institute (DE), and Dr. D. Meuwly at Netherlands Forensic Institute. At the national and nordic level the applicant collaborates with other image analysis and signal processing research groups on PhD education, e.g. in average 3 PhD exam committee membership per year, PhD internships at Finish Forensic Laboratory and Swedish Forensic Laboratory.

The applicants will host the International Conference in Biometrics-ICB in 2016 in Halmstad, which is the premier conference of the field, expected to attract more than 150 participants.

6 Previous own results of relevance

A recent result is forensic fingerprint recognition that has been shown to tangibly improve minutia constellation based recognition by using orientation fields and their sparse representations, [34]. This has enabled a novel automatic way of counting ridges. Using orientation estimation but in the logarithmic scale space of the Structure Tensor seems to give access to spatial frequency, [34, 2]. An in depth investigation of this phenomenon is however reserved to the present project. These results are encouraging for the project because they indicate that systematic completition of the description offered by orientation and frequency fields contain unexploited novel information.

The applicant's group has contributed to fundamentals of directional analysis, in 2D images as well as their higher dimensional relatives, e.g. MRI and X-Ray tomography, the most significant being the structure tensor, [9], which is related to the wave nature of images. It is being used by many applications as a way to obtain dense orientation maps with built-in estimation of quality measures. Nearly all fingerprint processing currently use the structure tensor, e.g. for enhancement or recognition.

We have proposed the generalized structure tensor, [7] introducing geometric transformations into the ordinary structure tensor. Originally an analysis tool, this turned recently to be useful to robotics via its theory producing synthesis of visual codes, [40]. The results suggest that spiral curves can create rotation and scale invariant markers, similar to bar codes but can be detected at larger distance variations and from more diverse view angles. The codes create tags, each with its own identity, allowing to recognize specific points on walls, on robots or on moving parts by cameras, Fig. 1 (4A, 4B), e.g. for navigation and tracking. Recognizability of such codes in adverse conditions is related to particle natures of images. It is expected that the nature of local images will allow to extract analogues of such codes, without tagging them. Our initial results [34, 2] are supportive to that. Periocular recognition contributions of the applicants are very competitive [37], among the highest ranked in international iris recognition benchmarks [44].

Tangible progress in multimodal fusion has been made under the auspices of a previous European project, M2VTS, to which the applicant contributed as a co-founder as well as a technology provider, [6]. It has introduced one of the most accurate eye and mouth detection, tracking as well as authentication systems [31] using a new paradigm, the artificial eye performing saccades in images. The group members were initiators of individual signal quality measures as well as automatic liveness measures, [8], to improve biometric recognition. They are also at the forefront of fingerprint quality assessment [3], expert conciliation [6], and cross-matching of signals based on quality measures [4], with leading rankings in benchmarks [36].

The applicant's group has also positioned itself as provider of high quality dense motion maps and their compact descriptions, e.g for joint lip-motion and speech analysis, [18, 25], with hundreds of downloads: http://www.mathworks.com/matlabcentral/profile/authors/3000288-stefan-karlsson.

7 Contributions of the proposal to advance the state of the art

Major contributions to the state of the art are estimated to be as follows.

- *Enable new applications by powerful and sparse signal representations for pattern recognition.* The project will *enable* applications having more powerful visual intelligence, especially in forensics and biometric identification, but also in mobile devices and robotics. It will provide a layered computation-grid combining non-linearities with linear filtering useful for thin clients.
- *Improved understanding of phase, orientation, and frequency/size maps in pattern recognition.* We will press more information from such maps by stratifying the nature (particle, wave) of local images by orientation cardinality.
- *Improved understanding of local image transformations, e.g. modeled by [9, 12, 7, 17].* The (non-linear) generalized structure tensor will likely offer novel venues to sparsify further the Hilbert space based (linear) descriptions of images for *recognition in images*.
- *The signal processing models will likely help to understand human vision.* How humans analyze joint orientation occurrence is not well understood. In case of moving bars, the study [1] points at (vectorial) superposition of motions, but this is not self-evident to extend to still images. The output of the project is expected to offer tools and insights into human vision and to open new research opportunities.

8 Budget

The project duration is four years. The applied funding will cover the salary costs of 1 PhD student (100 %), the co-applicant (50 %) and the applicant (30%), including the compulsory indirect costs of salaries. Approximately 91% of the cost represents salaries. The remainder will cover conference registration fees, travel expenses, publication expenses, e.g. journal fees, and software licenses and sensor costs, (cameras).

9 Current Personnel

The Signal Analysis research group currently consists of 4 researchers: 1 Professor (applicant) with +30 years of experience in image analysis, 1 post-doc (co-applicant) with 13 years of experience, 1 lecturer (Dr. Kenneth Nilsson), with 18 years of experience, and 1 PhD student (Anna Mikaelyan). Dr. Nilsson, who will fill 65 during the project, will be engaged full time in teaching including student supervisions. A. Mikaelyan is expected to finish her PhD before the project starts.

Halmstad University, being a small university is not allocated (state awarded) faculty-funding for meritorious research in the same (relative) amounts as larger universities in Sweden. This means that its basic research, as exemplified by the present proposal, must be financed by external funding.

Qualifications of group members comprise tangible international experience from research in other countries with several years of staying (Switzerland, Spain), to have been entrusted to be associate, or guest-editors of numerous journals, e.g. in Pattern Recognition Letters (PRL), Image, Machine Applications and Vision (IMAVIS), IEEE transactions on Information Forensics and Security (IFS), IEEE transactions on Image Processing, being co-authors of several invited papers, being keynote speakers in large conferences. The group members have been awarded with several high profile prizes and recognitions.

10 Current funding

The applicant has no external project funds currently. The co-applicant has currently Research Grant for young researchers (from Swedish VR) which ends in 2016.

11 Gender equality

Female candidates will be encouraged to apply. Equal opportunities will be offered to both genders.

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Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

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Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project

	Role in the project	Name	Percent of full time
1	Applicant	Josef Bigun	30
2	Participating researcher	Fernando Alonso-Fernandez	50
3	PhD Student	x	100

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	2018	2019	Total
1	Applicant	Josef Bigun	30	327,744	337,577	347,704	358,135	1,371,160
2	Participating researcher	Fernando Alonso-Fernandez	50	325,556	335,322	345,382	355,744	1,362,004
3	Other personnel without doctoral degree	X	100	442,680	460,387	486,948	513,509	1,903,524
	Total			1,095,980	1,133,286	1,180,034	1,227,388	4,636,688

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

	Type of premises	2016	2017	2018	2019	Total
1	Rental cost of premises (office rooms)	86,400	86,400	86,400	86,400	345,600
	Total	86,400	86,400	86,400	86,400	345,600

Running Costs

	Running Cost	Description	2016	2017	2018	2019	Total
1	Publication expenses	Journal fees (Open Access, etc.)	30,000	30,000	30,000	30,000	120,000
2	Travel costs	Conferences (registration fees and travel expenses)	90,000	90,000	90,000	90,000	360,000
3	Equipment	Sensors, cameras, laptops and related hardware	40,000	40,000	40,000	40,000	160,000
4	Overheads on salary costs		447,160	462,381	481,454	500,774	1,891,769
	Total		607,160	622,381	641,454	660,774	2,531,769

Depreciation costs

Depreciation cost	Description	2016	2017	2018	2019

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	2018	2019	Total, applied	Other costs	Total cost
Salaries including social fees	1,095,980	1,133,286	1,180,034	1,227,388	4,636,688		4,636,688
Running costs	607,160	622,381	641,454	660,774	2,531,769		2,531,769
Depreciation costs					0		0
Premises	86,400	86,400	86,400	86,400	345,600		345,600
Subtotal	1,789,540	1,842,067	1,907,888	1,974,562	7,514,057	0	7,514,057
Indirect costs					0		0
Total project cost	1,789,540	1,842,067	1,907,888	1,974,562	7,514,057	0	7,514,057

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

The project duration is four years.

The applied funding will cover the salary costs of 1 phd student (100 %), the co-applicant (50 %) and the applicant (30%), including social fees. The compulsory indirect/running costs of salaries (rental fees, and university overhead) are reported explicitly and conform to Halmstad University standards.

Travel costs will cover attendance to conferences of the project members (registration fees and travel expenses), and other foreseeable trips such as short visits to other laboratories.

Publication costs refer to Open Access fees (in accordance with VR´s policy on open access publishing)

Equipment costs refer to sensors and cameras, and software license fees, and associated hardware, e.g. storage such as hard disks for images, and backups.

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017	2018	2019

CV

Curriculum Vitae, 27-03-2015

Personal Details

Born:	08-01-1961
Nationality:	Swedish
Family:	Wife, and two children (born 1996, and 2013)
Languages:	Swedish, English, French, German, Aramaic

Education

Linkoeping University, Sweden (Supervisor G. Granlund)	Computer Vision PhD.	1988
Linkoeping University, Sweden	Applied Mathematics MSc.	1983

Appointments

Halmstad University, **HH**, and **Chalmers** Univ. of Techn. Goeteborg	(full) Professor	1999-
Ecole Polytechnique Federale, Lausanne, **EPFL**	Adjoint Scientifique (Senior Scientist)	1998-1998
Kungliga Tekniska Hoegskolan, Stockholm, Sweden	Gaest (Guest) Professor	1997-1997
Ecole Polytechnique Federale, Lausanne, **EPFL**	Adjoint Scientifique (Senior Scientist)	1993-1997
Ecole Polytechnique Federale, Lausanne, **EPFL**	Chercheur (Researcher)	1988-1993
Linkoeping University, **LiU**	PhD Student Dep. EE & assistant Dep. Math.	1983-1988

Publication summary

- **Scientific Production** Authored/Co-authored ≈150 reviewed publications of which 35 are journal articles. Co-authored 6 patents, edited 7 books, edited 4 special issues of journals.
- **Scientific Impact** i) Google Scholar: **h-index 34**, **˜5000 citations**, ii) Thomson ISI: **h-index 17**, **˜1100 citations**.
- **Society Impact** Articles in english and swedish written by journalists in daily/popular press on his research e.g. New Scientist (UK), Technology Review (USA), Metro (Stockholm). Articles in non-english languages written by journalists, among others in Switzerland, Italy, Germany, Slovakia and Vietnam.

Distinctions and Commissions of Trust

- i) *Fellow of* **IEEE** since 2003 and ii) *Fellow of Int. Association of Pattern Recognitition,* **IAPR***,* since 2000,
- PhD Exam committee member for 2-4 thesis defenses per year since 1999, in Sweden, Denmark, Finland, Spain, Switzerland or Netherlands.
- Journal editorial membership: **Currently**, Image vision and Computing; **Previously**, Pattern Recognition Letters (Elsevier), IEEE transactions on Image Processing (IEEE). Guest editor of the above, and IEEE Information Forensics, and Security
- invited lectures i) International Conference on Pattern Recognition, USA, 2008 (plenary, 1200 participants) ii) Workshop on Multimodal User Authentication, Santa Barbara, USA, December, 2003 iii) Int. conf. on image analysis and processing, Mantova, Italy, sep. 2003 iv) Scandinavian conference on image analysis Bergen, Norway, 2001, (Plenary, 300 participants) v) Dags-Stuhl (Germany) conference on image databases 1999, and on tensor visualization 2007 vi) Nato-Asi conference on face recognition 1997
- Was elected twice to the executive committee of the **IAPR**, (≈ 10'000 members) 1994-1996, 1996-1998,
- Received Saab-Combitech prize in image analysis, Sweden, 1985

Pedagogic merits: Research Supervision

- Supervised **13** PhD students up to graduation. (**Denmark**-Aalborg: Ole Hansen 1992; **Switzerland**-EPFL: Serge Ayer 1995, Philippe Schroeter 1996, Benoit Duc 1997, Stefan Fischer 1997; Fabrizio Smeraldi 2000; **Sweden**-Chalmers&Halmstad: Kenneth Nilsson 2005, Hemakumar Lalith Premaratne 2005, Maycel Isaac Faraj 2008, Hartwig Fronthaler 2008, Klaus Kollreider 2008, Yaregal Assabie 2009, Dereje Teferi 2009)
- Authored 1 text book (Vision with Direction, Springer, 2006), unifying orientation analysis theories

Pedagogic merits: up-to Master level

- Conceived and taught the courses, i) image analysis and ii) computer vision in 3D (HH, 1999-present). Produced the necessary lecture material, lab exercises and course-book (*Vision with Direction, Springer, 2006*). Conceived and taught the robot vision part of the course "Construction of intelligent embedded systems" (HH 2009-present). Taught math courses, including calculus and algebra (Linköping University, 1984-1985).
- Have been supervising ≈ 2 master thesis projects/annum up-to graduation, since 1988, (at EPFL, and HH).
- Co-director and lecturer of the *Summer School for Advanced Studies on Biometrics: Authentication and Recognition*, Alghero, Italy, June 2003–2012

External Fund Merits Summary

- **Switzerland and France:** Thomson-EPFL , Motion analysis 1991-1994. Principal investigator and author of the project proposal. ≈ 500 KCHF for EPFL; EPFL-UNIL (Switzerland), Ornament image databases 1995-1996. Principal investigator and author of the project proposal. ≈ 100 Kchf for EPFL; National Science Foundation (Switzerland), Content oriented querying of multimedia data bases: enhancing perceptually significant syntactic similarity, 1997-1998. Scientific Adviser and co-author of the project. ≈ 150 KCHF for EPFL; **Total 0.6 MEUR**
- **Europe** Acts-M2VTS , Multi-modal verification for tele-services and security, 1995-1998. Co-initiator of the consortium, Principal investigator and co-author of the project ammounting ≈ 700 KCHF for EPFL (Total ≈ 10 Million CHF involving 14 partners, globally financing at least 25 researchers in Europe for 3 years); IT-VIRSBS, Visual intelligent recognition for secure banking services. 1996-1998. Co-initiator, Principal investigator and co-author of the project ≈ 350 KCHFo for EPFL; Network of Excellence, (EU-FP6) 2004-2007. Biometrics for secure authentication, BIOSECURE, Principal investigator and co-author of the project ≈ 0.6 MSEK for HH; 1 EU Marie Curie postdoc, Iris identification, co-investigator and co-author of the project ≈ 1.6 MSEK for HH; Fp7-BBFOR2, BBfor2–Bayesian Biometrics For Forensics 2010-2012 Co-initiator, Principal investigator and co-author of the project ≈ 2.2 MSEK for HH; COST 275 (1999-2005), Biometrics-based recognition of people over internet, COST 2101 (2006-2011) Biometrics for Identity Documents and Smart Cards, and COST IC1106 (2012-2016) Integrating Biometrics and Forensics for the Digital Age ≈ 0.3 MSEK in travel grants; **Total 1.4 MEUR**
- **Sweden** Swedish Strategic Research Foundation, SSF-VISIT, project Image content retrieval for biometric applications. 2000-2002. Principal investigator and co-author of the project ≈ 1 MSEK for HH; Research School in Genomics and Bioinformatics (Sweden), sub-project, Databases with image content query and retrieval for proteomics. 2002-2005. Principal investigator and author of the project ≈ 2 MSEK for HH; Swedish National Research Council, Biometric person authentication with integrated face, lip movements and speech 2004-2007. Principal investigator and author of the project ≈ 2.4 MSEK for HH; Swedish International Development Cooperation Agency (SIDA) 1999-2009. Optical character recognition and biometrics as development cooperation between Sweden and Sri Lanka, and between Sweden and Ethiopia, Principal investigator and author of the project ≈ 4 MSEK for HH; Swedish National Research Council, Biometric person authentication with integrated face, lip movements and speech 2010-2011. Principal investigator and author of the project ≈ 2.4 MSEK for HH; National Research Council (Vetenskapsrådet, Sweden) post-doc project; Bio-distance, Biometrics at distance 2009-2011. co-investigator and co-author of the project ≈ 1.4 MSEK for HH; National Research Council (Vetenskapsrådet, Sweden), Scale, orientation and illumination invariant information encoding and decoding–A study on invariant visual codes 2012-2014. Principal investigator and author of the project ≈ 2.4 MSEK for HH; **Total 1.8 MEUR**

Industry and Leadership Merits

- Co-authored **6 patents corresponding to 4 inventions, cited more than 130 times (Google Scholar);**
- Leader for the core research package of the EU-M2VTS project, (8 research partners)
- Co-founded BigSafe Technology AB: Consulting services on risk analysis and management, including biometrics;
- Licensed software for face-recognition and face-tracking technologies e.g. to Omron Corporation (inc. Tokyo);

Other qualifications

- Invited to co-chair an EU research coordination workshop "Paving the way for the adoption of biometrics" - Brussels, 15 January 2002
- Co-director and/or lecturer of the *Summer School for Advanced Studies on Biometrics: Authentication and Recognition*, Alghero, Italy, June 2003, 2005, 2006, 2008, 2010, 2011, 2012
- (Co-)chaired **i)** the *first* international conference on *audio and video based biometric person authentication, AVBPA*, March 12-14 1997, Crans-Montana, Switzerland, (*Proceedings: Springer LNCS No. 1207*) **ii)** the *third* international conference on *audio and video based biometric person authentication, AVBPA*, June
- Chaired the TC 14 of IAPR (Signal Analysis for Machine Intelligence) 1998–2000, 2000-2002 6-8 2001, Halmstad, Sweden, (*Proceedings: Springer, LNCS No. 2091*) **iii)** the *13'th* Scandinavian conference on *image analysis, SCIA*, June 29-July 2 2003, Gothenburg, Sweden, (*Proceedings: Springer, LNCS*) **iv)** the track *Image Processing* of the *17'th* International conference on *Pattern Recognition, ICPR* , Aug 23-26 2004, Cambridge, UK, (*Proceedings: IEEE Computer Society*) **v)**the track *Biometrics* of the *18'th* International conference on *Pattern Recognition, ICPR* , Aug 20-24 2006, Hong Kong, CN, (*Proceedings: IEEE Computer Society*)
- Served in the program and/or organization committees of ≈ 40 international conferences including ICIP (≈ 1200 participants) and ICPR (≈ 1200 participants).
- Reviewed funding and promotion applications in Switzerland, Hong Kong, Austria, Sweden as well as EU

Higher education degree (year/subject area): Ph.D. Telecommunications Engineering (2008)

Doctoral degree (including awards)

2008: Ph.D. Telecommunications Engineering "***cum laude***" with **Doctor Europeus mention (15 citations)**
Thesis: "Biometric Sample Quality and its Application to Multimodal Authentication Systems"
Univ. Politecnica Madrid (UPM, Spain) (Supervisor: Prof. Javier Ortega-Garcia)

- 2011: Extraordinary Award by Univ. Politecnica Madrid to outstanding PhD Thesis
- 2010: Award "Best PhD Thesis on ICT for Banking" Spanish College Telecomm. Engineers (COIT)

Postdoctoral work and current position (including grants and scholarships)

2010 – Present: Postdoctoral Fellow, Halmstad University (HH), Sweden (research 1 FTE)

- 2010 – 2011: Grant for postdoctoral positions in Sweden, Swedish Research Council, ~1.4MSEK
- 2011 – 2013: EU FP7 Marie Curie Intra-European Fellowship, ~173k€
- 2013 – 2016: Project Research Grant for young researchers, Swedish Research Council, ~3.3MSEK (sole HH applicant who received funding, sole project in image analysis in Sweden of 448 awarded)

2008 – 2010: Postdoctoral Fellow, UPM, Spain (research 1 FTE, 80hours/year for teaching)

- Postdoctoral Scholarship from the Spanish Ministry of Innovation and Science, ~100k€

Qualification required for appointment as a docent

- 2015: Applied for qualification as Associate Professor ("docent") at Halmstad University (including mandatory courses on "Teaching and Learning in Higher Education I and II", 15 credits)
- 2009: qualified as Assistant Professor ("Ayudante Doctor") by the Spanish Ministry of Education (mandatory qualification to apply for Assistant Professor positions in Spanish public universities)

Previous positions and periods of appointment (including grants and scholarships)

2004 – 2008: Research Assistant (pursuing the PhD), UPM, Spain (Prof. Javier Ortega-Garcia)

- Ph.D. Scholarship from Comunidad de Madrid, partially funded by the EU, ~52k€
- Scholarship for a Research Internship at Univ. of Kent, UK in 2006, UPM, 4,500€

2001 – 2003: Undergraduate Research Assistant (pursuing the MSc), UPM, Spain (Prof. Javier Portillo)

- Undergraduate Research Scholarship, Spanish Ministry of Education, ~ 2k€

Supervision of PhD students: Anna Mikaelyan (2011-15, Halmstad, *Forensic Biometrics*, funded by Marie Curie ITN BBfor2); Pedro Tome (MSc 2008-09, PhD 2009-10, Madrid, continued by Dr. Fierrez after I left, *Biometrics at a Distance*, doctoral grant of Madrid Univ., Summa Cum Laude, now at IDIAP-EPFL, CH)

Supervision of 8 MSc STUDENTS up to graduation (some of Madrid from Sweden after I left UPM):

- 5 in Telecomm. Engineering (Madrid, 2007-12), 3 in Embedded & Intelligent Systems (Halmstad, 2013-)

Opponent of 8 MSc students in Embedded & Intelligent Systems (Halmstad, '10-'14);

Reviewer funding applications: *Evaluation Agency of Andalucía* ('08, '09), *Croatian Science Foundation* ('15)

Research Projects (besides own PhD/postdoc grants), incl. technical/financial management

Participated in 17 public projects and 17 contracts with companies, only most relevant given here:

- Swedish Knowledge Foundation: CAISR "Centre for Applied Intell. Systems" (2012-19)
- EU-COST: Action IC1106 Biometrics & Forensics (2012-16, **Management Committee Substitute of Sweden**), Action 2101 Identity Documents (2006-11), Action 275 Biometrics over Internet (2004-05)
- EU-FP7 ITN BBfor2 "Bayesian Biometrics For Forensics" (2010-13, **funding PhD of A. Mikaelyan**)
- EU-FP6 Network of Excellence BioSecure "Biometrics for Secure Authenticat." (2004-07; **coordinator of WP6: database collection, see section "database creation"; coordinator of sub-project in WP7.3: fingerprint recognition**), Integrated Project BioSec "Biometrics and Security" (2004-05)
- Spanish Government: Bio-Challenge "Last-Generation Biometrics" (2009-10, **proposal co-writer**), BIO-PASS "User-convenient Biometrics" (2006-09, **co-writer**), BIOSECUR-ID "Multi-biometrics" (2004-06)
- Spanish Guardia Civil: AWIS "Forensic Writing ID" (2009, **co-writer and PI**), **developments deployed to Spanish security forces (2012, after I left UPM), and submitted to independent technology benchmarks (4NSigComp2010/SigComp2009, see section "benchmarks") with very remarkable results**
- Spanish BBVA bank: "On-line signature for Tablet PC" (2005, **co-writer and PI**)

Research Internships to several EU labs (those until 2007 were during the PhD)

- Jan-Apr/2015: Dept Communications & Computer Engineering, Malta Univ (Dr. Reuben Farrugia). Research on low resolution iris processing (short term mission within **project COST IC1106**)

- Jun/2014: Summer School for Advanced Studies on "Biometrics in Forensics Security and Beyond", University of Sassari, Alghero (Italy), 9-13 June 2014 (**selection based on CV**)
- Jul/2007: Institut National des Télécommunications, France (Prof. Sonia Garcia-Salicetti). Research on signature verification with regard to cultural origin of signatures.
- Nov/2006 – Feb/2007: Dep. of Electronics, Univ. of Kent, UK (Prof. Michael Fairhurst). Research on quality measures for off-line signature images (**2 conf papers, constituting a PhD thesis chapter**)
- May-July/2006: Dip. Ing. Elettrica ed Elettronica, Univ. Cagliari, Italy (Prof. Fabio Roli). Research on quality measures for fingerprint images (**1 journal + 1 conf publications, basis of a PhD chapter**)
- Oct-Dec/2005: Signals and Systems Dep., Univ. of Twente, The Netherlands (Prof. Raymond Veldhuis). Research on fingerprint verification (**2 conference publications**)
- Aug/2005: BioSecure Residential Workshop, Paris, France. Work on biometric recognition (fingerprint, signature and multimodal) (**4 journals, 2 book chapters from direct research or collaborations initiated**)

Teaching activities in MSc, PhD and other postgraduate courses

- PhD course Halmstad (2014-15: *Multi-scale &multi-dimensional Signal Analysis*). Conceived full course incl syllabus, teaching materials, exercises, and examination. Some video-lectures made available.
- PhD course in Madrid (2006-09: *Biometric Techniques Applied to Security*)
- MSc courses Madrid (2009: *Optimization & Simulation*, *Electronic Instrumentat*, *Telecomm Systems*; 2008: *Multimedia*; 2005-09: *Electronic Circuit Analysis*; 2005-06: *Advanced Computer Arquitectures*)
- Postgraduate Courses in Madrid (2007-09: *Forensic Sciences*; 2004-07: *Security Management*)
- Laboratory assistant as MSc student (1999: *Digital Electronic Systems*; 1998: *Electronic Circuits*)

Program Committee (incl reviewer) of Intl Conferences/Workshops on: *Biometrics* (ICB'12-15), *Image Proc* (ICIP'13-15), *Pattern Recog* (ICPR´10,12,14), *Signal Proc* (EUSIPCO'09,14), *Biometrics & Forensics* (IWBF´15), *Identity, Security & Behavior Analysis* (ISBA'15), *Bio-inspired Systems & Signal Proc* (BIOSIGNALS'11-15), *Bioimaging* (BIOIMAGING'14), *Computational Modeling of Objects in Images* (CompIMAGE'10)

Organisation of scientific meetings: *International Conference on Biometrics, ICB* (Halmstad, '16, **host** and **co-chair**, expected >150 attendees); *Workshop Multim. Crime Scene Forensics for Fingerprint Acquisition & Proc., MM4CSF* (Torino, '15, co-located with ICME'15, **Technical Committee**); *Intl Conf Biometric ID Management & Multimodal Communication*, BIOID (Madrid, '09, **Local Org Committee**); *ISCA Speaker & Language Recognition Workshop, ODYSSEY-04* (Toledo, '04, **Local Org Committee**)

Reviewer of Journals of high impact including: IEEE (Image Process.; Information Forensics & Security; Security & Privacy; Systems, Man & Cybernetics; Systems Journal; Signal Process. Letters; Digital Signal Proc.), SPIE (Optical Engineering; Electronic Imaging), Elsevier (Image & Vis Computing; Pattern Rec Letters; Computer Vis & Image Underst.; Network & Computer Apps; Digital Signal Proc; Information Sciences), Springer (Pattern Analysis & Apps; Information Fusion), IET (Biometrics), EURASIP (Information Sec.)

Invited talks: *Workshop Insight on Eye Biometrics*, Marrakech'14 (**invited paper**); *Norwegian Biometric Forum*, Oslo'13; *ISPA Conf, Special Sess Signal & Image Proc for Biometrics*, Salzburg'08 (**invited paper**); *COST 2101 Workshop Signature & Handwriting for Person ID*, Canterbury'07; *NIST Biometric Quality Workshop II* (Maryland'07)

Participation in technology benchmarks (with **developments of own research**, in several cases with **supervised students/co-workers**; submissions **usually ranked in first two positions**)

2013: ICIR-Competition on Iris Recognition, system ranked 2nd/13 (**1st among academic participants**)
2010: 4NSigComp2010-Signature Competition, forensic-like datasets, ranked 2nd/10 (**with 2 MSc students**)
2009: SigComp2009-Signature Competition, forensic-like datasets, ranked 2nd/15 (**with 2 MSc students**)
2009: LivDet-Fingerprint Liveness Detection, fake images from gummy fingers, ranked 3rd/4 (w. co-worker)
2009: BSEC-BioSecure Signature Evaluation, 2 scenarios, ranked 2nd/1st (of 14) (with co-worker)
2007: BMEC-Biosecure Multimodal Campaign, fusion under cross-device matching, 2 scenarios, ranked 2nd/1st (of 13/9 systems, respectively). **Data from BMDB database, see "database creation" below**.

Database creation (design and collection, some within EU projects or with students)

2014: iris segmentation data (10,000 images), with Salzburg University, described in joint conference publication and available at http://islab.hh.se/mediawiki/index.php/Iris_Segmentation_Groundtruth
2012: 2250 fake fingerprint images (with PhD student + journal), available http://atvs.ii.uam.es/ffp_db.html
2008: 800 fake iris images (with MSc student+conference paper), available http://atvs.ii.uam.es/fir_db.html
2008: BMDB multimodal data, 600 persons, 11 EU centers, as coordinator of WP6 (database collection) of EU-FP6 BioSecure (**journal paper, 2nd "most cited"), used in several technology benchmarks**

Publication list

(⋆) = Important to this project
Document names are clickable for reading[1].

Publications, 2015-March

The Citations counts are due to Google Scholar. Only counts above 20 are reported.
http://scholar.google.com/citations?user=KIdvOZYAAAAJ&hl=en
All publications (and pdf files of most publications) are also available at:
http://www2.hh.se/staff/josef/

The five most cited publications

[1] ⋆ J. Bigun, G.H. Granlund, and J. Wiklund. Multidimensional orientation estimation with applications to texture analysis and optical flow. *IEEE-PAMI*, 13(8):775–790, 1991.
bigun91pami.pdfNumber of Citations:574.

[2] J. Bigun and G.H. Granlund. Optimal orientation detection of linear symmetry. In *ICCV, London, June 8–11*, pages 433–438. IEEE Computer Society, 1987.
bigun87london.pdf Number of Citations:433.

[3] B. Duc, S. Fischer, and J. Bigun. Face authentication with Gabor information on deformable graphs. *IEEE Trans. on Image Processing*, 8(4):504–516, 1999.
duc99tip.pdf Number of Citations:232.

[4] E.S. Bigun, J. Bigun, B. Duc, and S. Fischer. Expert conciliation for multi modal person authentication systems by bayesian statistics. In J. Bigun, G. Chollet, and G. Borgefors, editors, *Audio and Video based Person Authentication - AVBPA97*, pages 291–300, Heidelberg, 1997. Springer.
bigune97avbpa.pdf Number of Citations:219.

[5] J. Fierrez-Aguilar, J. Ortega-Garcia, J. Gonzalez-Rodriguez, and J. Bigun. Discriminative multimodal biometric authentication based on quality measures. *Pattern Recognition*, 38:777–779, 2005.
fierrez05pr.pdf Number of Citations:204.

[1] In Adobe Acrobat turn on "Previous view" and "Next view" to navigate between this document and the referenced file names (View → Toolbars → More Tools)

Important but not in "five most-cited" nor within "8 years"

[1] ⋆ J. Bigun, T. Bigun, and K. Nilsson. Recognition by symmetry derivatives and the generalized structure tensor. *IEEE-PAMI*, 26:1590–1605, 2004.
bigun04pami3.pdfNumber of Citations:84.

Journal papers (chronological)

[1] F. Alonso-Fernandez, J. Fierrez-Aguilar, H. Fronthaler, K. Kollreider, J. Ortega-Garcia, J. Gonzalez-Rodriguez, and J. Bigun. Combining multiple matchers for fingerprint verification: A case study in Biosecure Network of Excellence. *Annals of Telecommunications, Special Issue on Multimodal Biometrics*, 62(1-2):61–82, 2007.
alonso-fernandez07aot.pdf.

[2] Y. Assabie and J. Bigun. Multifont size-resilient recognition system for ethiopic script. *International Journal on Document Analysis and Recognition*, 10(2):85–100, November 2007.
assabie07ijdar.pdf.

[3] ⋆ F. Alonso-Fernandez, J. Fierrez, J. Ortega-Garcia, J. Gonzalez-Rodriguez, H. Fronthaler, K. Kollreider, and J. Bigun. A comparative study of fingerprint image-quality estimation methods. *IEEE Transactions on Information Forensics and Security*, 2(4):734–743, 2007.
alonso-fernandez07tifs.pdf Number of Citations:141.

[4] M. Faraj and J. Bigun. Audio visual person authentication using lip-motion from orientation maps. *Pattern Recognition Letters*, 28(11):1368–1382, 2007.
faraj07prl.pdf Number of Citations:27.

[5] M. Faraj and J. Bigun. Synergy of lip motion and acoustic features in biometric speech and speaker recognition. *IEEE trans. Computers*, 56(9):1169–1175, 2007.
faraj07tc.pdf **Invited Paper** Number of Citations: 21.

[6] S. Karlsson and J. Bigun. Multiscale complex moments of the local power spectrum. *Journal of Opt. Society of America A*, 24(3):618–625, 2007.
karlsson07josa.pdf.

[7] K. Kollreider, H. Fronthaler, M. I. Faraj, and J. Bigun. Real time face detection and motion analysis with application in liveness assessment. *IEEE Trans. on Information Forensics and Security*, 2(3–2):548–558, September 2007.
kollreider07tifs.pdf Number of Citations:37.

[8] D. Teferi and J. Bigun. Damascening video databases for evaluation of face tracking and recognition - the dxm2vts database. *Pattern Recognition Letters*, 28(15):2143–2156, 2007.
teferi07prl.pdf.

[9] H. Fronthaler, K. Kollreider, and J. Bigun. Local features for enhancement and minutiae extraction in fingerprints. *Image Processing, IEEE Transactions on*, 17(3):354–363, 2008.
fronthaler08tip.pdf Number of Citations:80.

[10] H. Fronthaler, K. Kollreider, J. Bigun, J. Fierrez, F. Alonso-Fernandez, and J. Ortega-Garcia. Fingerprint image quality estimation and its application to multi-algorithm verification. *IEEE Transactions on Information Forensics and Security*, 3(2):331–338, 2008.
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[11] K. Kollreider, H. Fronthaler, and J.Bigun. Non-intrusive liveness detection by face images. *Image and Vision Computing*, 27(3):233–244, 2009.
kollreider09imavis.pdf Number of Citations:59.

[12] Y. Assabie and J. Bigun. Offline handwritten amharic word recognition. *Pattern Recognition Letters*, 32(8):1089 – 1099, 2011.
assabie11prl.pdf.

[13] ⋆ R. P. Krish, J. Fierrez, D. Ramos, J. Ortega Garcia, and J. Bigun. Pre-registration of latent fingerprints based on orientation field. *IET Biometrics*, 2015.
krish15ietbiometricsvalletta.pdf.

[14] F. Alonso-Fernandez and J. Bigun. Near-infrared and visible-light periocular recognition with gabor features using frequency-adaptive automatic eye detection. *Biometrics, IET*, 2015 (in press).
alonso-fernandez15ietbiometrics.pdf.

Conference papers (chronological)

[1] Y. Assabie and J. Bigun. A hybrid system for robust recognition of ethiopic script. In *Int. Conf. on Document Analysis and Recognition, ICDAR*, pages 556–560. IEEE Computer Society, September 23-26, Curitiba, Brazil 2007.
assabie07curitiba.pdf.

[2] Y. Assabie and J. Bigun. A neural network approach for multifont and size-independent recognition of ethiopic characters. In Sameer Singh and Maneesha Singh, editors, *Progress in Pattern Recognition-IWAPR2007*, Advances in Pattern Recognition, pages 129–137. Springer, July 21-23, Plymouth, UK 2007.
assabie07plymouth.pdf.

[3] M I Faraj and J. Bigun. Lip biometrics for digit recognition. In *International Conference on Computer Analysis of Images and Patterns, CAIP2007, LNCS 4673*, pages 360–366. Springer, 2007.
faraj07vienna.pdf.

[4] M. I. Faraj and J. Bigun. Speaker and digit recognition by audio-visual lip biometrics. In *The international conference on Biometrics (ICB) 27-29 Aug, Seoul, S. Korea*, pages 1016–1024. Springer, LNCS, 2007.
faraj07seoul.pdf.

[5] H. Fronthaler, K. Kollreider, and J. Bigun. Pyramid-based image enhancement of fingerprints. In *Fifth IEEE Workshop on Automatic Identification Advanced Technologies, AutoID*, pages 45–50. 7-8 June 2007.
fronthaler07alghero.pdf.

[6] K. Kollreider, H. Fronthaler, and J. Bigun. Real-Time Face Detection Using Illumination Invariant Features. In B. K. Ersboll and K. S. Pedersen, editors, *SCIA*, volume 4522 of *Lecture Notes in Computer Science*, pages 41–50. Springer, 2007. ISBN 978-3-540-73039-2.
kollreider07aalborg.pdf.

[7] D. Teferi and J. Bigun. Pyramid Based Interpolation for Face-Video Playback in Audio Visual Recognition. In S.W. Lee and S. Z. Li, editors, *The International Conference on Biometrics (ICB 2007) 27-29 Aug, Seoul, S. Korea*, pages 868–877. Springer, LNCS 4642, 2007.
teferi07seoul.pdf.

[8] D. Teferi, M. I. Faraj, and J. Bigun. Text Driven Face-Video Synthesis Using GMM and Spatial Correlation. In Bjarne Kjaer Ersboll and Kim Steenstrup Pedersen, editors, *The 15th Scandinavian Conference on Image Analysis (SCIA 2007), 10-14 June. Aalborg, Denmark.*, pages 572–580. Springer, LNCS 4522, June 2007.
teferi07aalborg.pdf.

[9] Y. Assabie and J. Bigun. Lexicon-based offline recognition of amharic words in unconstrained handwritten text. In *The 19th International Conference on Pattern Recognition (ICPR2008), December 8-11, Tampa, Florida, USA*. IEEE, December 2008.
assabie08tampa.pdf.

[10] Y. Assabie and J. Bigun. Online handwriting recognition of ethiopic script. In *Eleventh International Conference on Frontiers in Handwriting Recognition (ICFHR2008), August 19-21, Montreal, Quebec, Canada*, pages 153–158. Concordia University, Canada, August 2008.
assabie08montrealB.pdf.

[11] Y. Assabie and J. Bigun. Writer-independent offline recognition of handwritten ethiopic characters. In *Eleventh International Conference on Frontiers in Handwriting Recognition (ICFHR2008), August 19-21, Montreal, Quebec, Canada*, pages 652–657. Concordia University, Canada, August 2008.
assabie08montrealA.pdf.

[12] K. Kollreider, H. Fronthaler, and J. Bigun. Verifying Liveness by Multiple Experts in Face Biometrics. In *IEEE Computer Vision and Pattern Recognition Workshop on Biometrics, Anchorage, Alaska, USA*, pages 1–6. 28 June 2008.
kollreider08anchorage.pdf Number of Citations: 39.

[13] Y. Assabie and J. Bigun. Hmm-based handwritten amharic word recognition with feature concatenation. In *Int. Conf. on Document Analysis and Recognition, ICDAR, July 26-29, Barcelona, Spain,*, pages 961–965. IEEE Computer Society, 2009.
assabie09barcelona.pdf.

[14] D. Teferi and J. Bigun. Multi-view and multi-scale recognition of symmetric patterns. In A.-B. Salberg, J.Y. Hardeberg, and R. Jenssen, editors, *Scandinavian Conference on Image Analysis, SCIA-2009, LNCS 5575*, pages 657–666. Springer, 2009.
teferi09oslo.pdf.

[15] J. Bigun and S. M. Karlsson. Histogram of directions by the structure tensor. In *ISABEL'11*. ACM, 2011.
bigun11barcelona.pdf.

[16] F. Alonso-Fernandez and J. Bigun. Iris boundaries segmentation using the generalized structure tensor : A study on the effects of image degradation. In *The IEEE Fifth International Conference on Biometrics: Theory, Applications and Systems (BTAS 2012), Washington DC*. IEEE XPLORE, Sep. 23-26 2012.
alonso-fernandez12washingtondc.pdf.

[17] F. Alonso-Fernandez and J. Bigun. Periocular recognition using retinotopic sampling and gabor decomposition. In *ECCV Workshop "What's in a Face?" WIAF, Firenze, Italy*. Springer LNCS 7584, Oct. 7-13 2012.
alonso-fernandez12firenze.pdf.

[18] S. M. Karlsson and J. Bigun. Lip-motion events analysis and lip segmentation using optical flow. In *CVPR Workshop on Biometrics*. IEEE-XPLORE, Piscataway, NJ, June 18-21, 2012.
karlsson12providence.pdf.

[19] A. Mikaelyan and J. Bigun. Ground truth and evaluation for latent fingerprint matching. In *CVPR Workshop on Biometrics*. IEEE-XPLORE, Piscataway, NJ, June 18-21, 2012.
mikaelyan12providence.pdf.

[20] F. Alonso-Fernandez and J. Bigun. Eye detection by complex filtering for periocular recognition. In *International Workshop on Biometrics and Forensics*. Valletta, Malta, 2014.
alonso-fernandez14valletta.pdf.

[21] H. Hofbauer, F. Alonso-Fernandez, P. Wild, J. Bigun, and A. Uhl. A ground truth for iris segmentation. In *Proceedings of International Conference on Pattern Recognition–ICPR2014*. IEEE Computer Society, Piscataway, NJ, Stockholm 2014.
alonso-fernandez14stockholm.pdf.

[22] R. P. Krish, J. Fierrez, D. Ramos, J. Ortega-Garcia, and J. Bigun. Partial fingerprint registration for forensics using minutiae-generated orientation fields. In *International Workshop on Biometrics and Forensics*. Valletta, Malta, 2014.
krish14valletta.pdf.

[23] R. P. Krish, J. Fierrez, D. Ramos, J. Ortega-Garcia, and J. Bigun. Pre-registration for improved latent fingerprint identification. In *Proceedings of International Conference on Pattern Recognition–ICPR2014*. IEEE Computer Society, Piscataway, NJ, Stockholm 2014.
krish14stockholm.pdf.

Books, Edited Books, Special issues, Book Chapters (chronological)

[1] Special issue on multimodal biometrics. *IEEE T. on Information Forensics and Security*, 2(3):489–490, Sep 2007.
bhanu07tifs.pdf.

[2] Image and vision computing journal special issue on multimodal biometrics. *Image and Vision Computing*, 27(3):221–221, 2009.
tistarelli09imavis.pdf.

[3] F. Alonso-Fernandez, J. Bigun, J. Fierrez, H. Fronthaler, K. Kollreider, and J. Ortega-Garcia. Fingerprint recognition. In D. Petrovska-Delacrataz, G. Chollet, and B. Dorizzi, editors, *Guide to Biometric Reference Systems and Performance Evaluation*. Springer, Heidelberg, 2009.
alonso-fernandez09chapter.pdf.

[4] J. Bigun. Fingerprint features. In S. Z. Li, editor, *Encyclopedia of biometrics*, pages 465–473. Springer, Heidelberg, 2009.
bigun09enc_finger_feat.pdf.

[5] J. Bigun. Multiple experts. In S. Z. Li, editor, *Encyclopedia of biometrics*, pages 986–993. Springer, Heidelberg, 2009.
bigun09enc_multiple_experts.pdf.

[6] M. Faraj and J. Bigun. *Lip motion features for biometric person recognition*. Medical Information Science Reference. IGI Global, Hershey, PA, USA, 2009.
faraj09bookchapter.pdf.

[7] F. Alonso-Fernandez, J. Fierrez, and J. Bigun. Quality measures in biometric systems. In *Encyclopedia of Biometrics, 2nd edition :*. Second edition, 2013.
alonso_fernandez13enc.pdf.

Patents

[1] ⋆ D. Teferi and J. Bigun. Method and apparatus for encoding and reading optical machine-readable data codes. In *USA, (Filed 2010, awarded 2014-06-24)*, number US 8757490 B2. 2014.
https://www.google.com/patents/US8757490.

List of publications, last 8 years (2007-)

Older publications also included if they are among the most cited, regardless of year of publication

Citation data from Google Scholar

Impact figures (as of March 2015)
h-index of Google Scholar: 21 (1303 citations)

Five most important publications for the project marked with one asterisk (*): 2, 7, 8, 12, 20

Five most cited publications:
12 (141 citations), 7 (109 citations), 8 (75 citations), 45 (66 citations), 38 (60 citations)

Publications obtained as result of research internships or research work initiated during such internships marked with two asterisks (**): 10-12, 14-16, 42-44, 56, 57

Publications with supervised PhD/MSc students marked with 3 asterisks (***) and student name underlined: 1, 17, 18, 20, 30, 31, 33, 36-40, 46-49

Peer-reviewed articles (journals)

[1]. (***) A. Mikaelyan, **F. Alonso-Fernandez**, J. Bigun, "Keypoint Description by Symmetry Assessment – Applications in Biometrics", submitted to *IEEE Transactions on Information Forensics & Security* (2nd round of review)

Number of citations:

[2]. (*) **F. Alonso-Fernandez**, J. Bigun, "Near-Infrared and Visible Light Periocular Recognition with Gabor Features using Frequency-Adaptive Automatic Eye Detection", *IET Biometrics*, in press (**from a conference paper selected as one of the best papers in IWBF 2014, and invited to submit an extended version**)

Number of citations:

[3]. **F. Alonso-Fernandez,** J. Fierrez, J. Ortega-Garcia, "Quality Measures in Biometric Systems", *IEEE Privacy & Security Magazine*, 10 (6): 52-62, Nov-Dec 2012, ISSN: 1540-7993

Number of citations: 20

[4]. J. Galbally, **F. Alonso-Fernandez**, J. Fierrez, J. Ortega-Garcia, "A High Performance Fingerprint Liveness Detection Method Based on Quality Related Features", *Elsevier Future Generation Computer Systems Journal*, 28 (1): 311-321, 2012, ISSN 0167-739X

Number of citations: 48

[5]. J. Galbally, J. Fierrez, **F. Alonso-Fernandez**, M. Martinez-Diaz, "Evaluation of Direct Attacks to Fingerprint Verification Systems", *Springer Journal of Telecommunication Systems, Special Issue of Biometrics Systems & Applications*, 47 (3): 243-254, 2011, ISSN 1018-4864

Number of citations: 35

[6]. **F. Alonso-Fernandez**, J. Fierrez, D. Ramos, J. Ortega-Garcia, J. Gonzalez-Rodriguez, "Quality-Based Conditional Processing in Multi-Biometrics: Application to Sensor Interoperability", *IEEE Trans. On Systems, Man & Cybernetics, part A*, 40 (6): 1168-1179, November 2010, ISSN 1083-4427

Number of citations: 28

[7]. (*) J. Ortega-Garcia, J. Fierrez, **F. Alonso-Fernandez**, *et al*. "The Multi-Scenario Multi-Environment BioSecure Multimodal Database (BMDB)", *IEEE Trans. Pattern Analysis &*

Machine Inteligence., 32 (6): 1097-1111, June 2010, ISSN: 0162-8828

Number of citations: 109

[8]. (*) *N. Poh, T. Bourlai, J. Kittler, L. Allano*, **F. Alonso-Fernandez**, *et al*. "Benchmarking Quality-dependent and Cost-sensitive Score-level Multimodal Biometric Fusion Algorithms", *IEEE Trans. on Information Forensics and Security*, 4 (4): 849-866, Dec. 2009, ISSN: 1556-6013

Number of citations: 75

[9]. J. Fierrez, J. Galbally, J. Ortega-Garcia, M. R. Freire, **F. Alonso-Fernandez**, *et al*. "BiosecurID: A Multimodal Biometric Database", *Pattern Analysis and Applications*, 13 (2): 235-246, May 2010, ISSN: 1433-7541

Number of citations: 54

[10]. **(**) F. Alonso-Fernandez**, *F. Roli, G.L. Marcialis*, J. Fierrez, J. Ortega-Garcia, J. Gonzalez-Rodriguez, "Performance of fingerprint quality measures depending on sensor technology", *SPIE Journal of Electronic Imaging,* Vol. 17, n. 1, Jan–Mar 2008, ISSN: 1017-9909

Number of citations: 16

[11]. **(**)** *H. Fronthaler, K. Kollreider, J. Bigün*, J. Fierrez, **F. Alonso-Fernandez**, J. Ortega-Garcia, J. Gonzalez-Rodriguez, "Fingerprint Image Quality Estimation and its Application to Multi-Algorithm Verification", *IEEE Trans. on Information Forensics and Security*, 3(2): 331-338, 2008

Number of citations: 57

[12]. (*) (**) **F. Alonso-Fernandez**, J. Fierrez, J. Ortega-Garcia, J. Gonzalez-Rodriguez, *H. Fronthaler, K. Kollreider, J. Bigün*, "A comparative study of fingerprint image-quality estimation methods", *IEEE Trans. on Information Forensics and Security*, Vol. 2, n. 4, pp. 734-743, December 2007

Number of citations: 141

[13]. **F. Alonso-Fernandez**, J. Fierrez-Aguilar, J. Ortega-Garcia and J. Gonzalez-Rodriguez, "Secure access system using signature verification over Tablet PC", *IEEE Aerospace and Electronic Systems Magazine*, Vol. 22, n. 4, pp. 3-8, April 2007, ISSN: 0885-8985

Number of citations: 11

[14]. **(**) F. Alonso-Fernandez**, J. Fierrez-Aguilar*, H. Fronthaler, K. Kollreider*, J. Ortega-Garcia, J. Gonzalez-Rodriguez and *J. Bigün*, "Combining multiple matchers for fingerprint verification: A case study in Biosecure Network of Excellence", *Annals of Telecommunications, Special Issue on Multimodal Biometrics*, Vol. 62, n. 1-2, pp. 62-82, January-February 2007, ISSN: 0003-4347

Number of citations: 8

[15]. **(**)** *S. Garcia-Salicetti*, J. Fierrez-Aguilar, **F. Alonso-Fernandez**, *et al*., "Biosecure reference systems for on-line signature verification: A study of complementarity", *Annals of Telecommunications, Special Issue on Multimodal Biometrics*, Vol. 62, n. 1-2, pp. 36-61, January-February 2007, ISSN: 0003-4347

Number of citations: 27

Peer-reviewed international conference contributions (participation in conference given)

[16]. (**) **F. Alonso-Fernandez,** *R. A. Farrugia*, J. Bigun, "Eigen-Patch Iris Super-Resolution For Iris Recognition Improvement", *Proc. 23rd European Signal Processing Conference, EUSIPCO,* Nice, France, 31 August - 4 September 2015

[17]. (***) A. Ranftl, **F. Alonso-Fernandez**, S. Karlsson, "Face Tracking Using Optical Flow. Development of a Real-Time AdaBoost Cascade Face Tracker", *Proc. 19th Scandinavian Conference on Image Analysis, SCIA,* Copenhagen, Denmark, 15-17 June, 2015

[18]. (***) **F. Alonso-Fernandez,** A. Mikaelyan, J. Bigun, "Comparison and Fusion of Multiple Iris and Periocular Matchers Using Near-Infrared and Visible Images", *Proc. 3rd COST IC1106 International Workshop on Biometrics and Forensics*, *IWBF*, Gjovik, Norway, 3-4 March, 2015

(**Oral**)

[19]. **F. Alonso-Fernandez**, J. Bigun, "Fake Iris Detection: A Comparison Between Near-Infrared and Visible Images", *Proc. Workshop on Insight on Eye Biometrics*, IEB, in conjunction with the *Intl Conf on Signal Image Technology & Internet Based Systems*, SITIS, Marrakech, Morocco, 23-27, Nov 2014 (**Oral**)

[20]. (*) (***) A. Mikaelyan, **F. Alonso-Fernandez**, J. Bigun, "Periocular Recognition by Detection of Local Symmetry Patterns", *Proc. Workshop on Insight on Eye Biometrics*, IEB, in conjunction with the *Intl Conf on Signal Image Technology & Internet Based Systems*, SITIS, Marrakech, Morocco, 23-27, Nov 2014 (**Oral**) (**invited paper**)

[21]. *M. Zhang, J. Liu, Z. Sun, W. Su*, **F. Alonso-Fernandez**, *V. Némesin, N. Othman, K. Noda, P. Li, E. Hoyle, A. Joshi*, "The First ICB Competition on Iris Recognition", *Proc. IEEE/IAPR International Joint Conference on Biometrics, IJCB*, Clearwater (Tampa), FL, 29 Sept – 2 Oct, 2014

[22]. **F. Alonso-Fernandez,** J. Bigun, "Best Regions for Periocular Recognition with NIR and Visible Images", *Proc. IEEE International Conference on Image Processing*, *ICIP*, Paris, France, 27-30 October, 2014 (**Poster**)

[23]. **F. Alonso-Fernandez,** J. Bigun, "Exploting Periocular and RGB Information in Fake Iris Detection", *Proc. 37th International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO, Special Session on Biometrics & Forensics & De-identification and Privacy Protection*, *BiForD*, Opatija, Croatia, 26-30th May, 2014 (**Oral**)

[24]. **F. Alonso-Fernandez,** J. Bigun, "Eye Detection by Complex Filtering for Periocular Recognition", Proc. *2nd COST IC1106 International Workshop on Biometrics and Forensics*, IWBF, Valletta, Malta, 27-28th March, 2014 (**Oral**) (**selected as one of the best papers, invited to submit an extended version for publication in the IET Biometrics Journal**)

Number of citations: 2

[25]. *H. Hofbauer*, **F. Alonso-Fernandez**, *P. Wild*, J. Bigun, *A. Uhl*, "A Ground Truth for Iris Segmentation", *Proc. 22nd International Conference on Pattern Recognition*, *ICPR*, Stockholm, August 24-28, 2014

Number of citations: 1

[26]. **F. Alonso-Fernandez,** J. Bigun, "Quality Factors Affecting Iris Segmentation and Matching", Proc. *6th IAPR Intl Conf on Biometrics*, ICB, Madrid, June 4-7, 2013 (**Oral**)

Number of citations: 2

[27]. **F. Alonso-Fernandez**, J. Bigun, "Periocular Recognition Using Retinotopic Sampling and Gabor Decomposition", Proc. *Intl Workshop "What's in a Face?"* WIAF, in conjunction with the *European Conference on Computer Vision*, ECCV, Springer LNCS-7584, pp. 309-318, Firenze, Italy, October 7-13, 2012 (**Poster**)

Number of citations: 6

[28]. **F. Alonso-Fernandez**, J. Bigun, "Iris Boundaries Segmentation Using the Generalized Structure Tensor. A Study on the Effects on Image Degradation", Intl Conf on Biometrics: Theory, Apps and Systems, BTAS, Washington DC, September 23-26, 2012 (**Oral**)

Number of citations: 5

[29]. **F. Alonso-Fernandez**, Julian Fierrez, Javier Galbally, Javier Ortega-Garcia, "Exploiting Character Class Information in Forensic Writer Identification", *Intl Workshop on Computational Forensics, IWCF10*, Tokyo, Japan, November 11-12, 2010

Number of citations: 1

[30]. **(***)** R. Fernandez-de-Sevilla, **F. Alonso-Fernandez**, J. Fierrez, J. Ortega-Garcia, "Forensic Writer Identification Using Allographic Features", *Intl Conf on Frontiers in Handwriting Recognition, ICFHR*, Kolkata, India, November 16-18, 2010

Number of citations: 8

[31]. **(***)** P. Tome, J. Fierrez, **F. Alonso-Fernandez** and J. Ortega-Garcia, "Scenario-Based Score Fusion for Face Recognition at a Distance", *IEEE Computer Society Workshop on Biometrics,* in association with *CVPR'2010*, San Francisco, CA, June 18, 2010

Number of citations: 8

[32]. D. Ramos, **F. Alonso-Fernandez**, "A Practical Electronic Instrumentation Course for Engineering Students", *IEEE Global Engineering Education Conference EDUCON – The Future of Global Learning Engineering Education*, Madrid, Spain, April 14-16, 2010

Number of citations: 1

[33]. **(***) F. Alonso-Fernandez**, P. Tome-Gonzalez, V. Ruiz-Albacete, J. Ortega-Garcia, "Iris Recognition Based on SIFT Features", *IEEE Intl Conf Biometrics, Identity&Security, BIDS*, Tampa, Sep 09 **(Oral)**

Number of citations: 37

[34]. J. Galbally, **F. Alonso-Fernandez**, J. Fierrez, J. Ortega-Garcia, "Fingerprint Liveness Detection Based on Quality Measures", *IEEE Intl. Conf. Biometrics, Identity & Security, BIDS*, Tampa, Sep 09 **(Oral)**

Number of citations: 8

[35]. **F. Alonso-Fernandez**, J. Fierrez, M. Martinez, J. Ortega-Garcia, "Fusion of static image and dynamic information for signature verification", *IEEE Intl Conf Image Process., ICIP*, Egypt, Nov 09 **(Oral)**

Number of citations: 9

[36]. **(***) F. Alonso-Fernandez**, J. Fierrez, A. Gilperez, J. Ortega-Garcia, "Impact of time variability in off-line writer identification and verification", *IEEE Intl Symp Image & Signal Processing & Analysis, ISPA, Spec Sess Signal Image Processing for Biometrics*, Salzburg, Sept 2009 **(Oral, invited paper)**

Number of citations: 7

[37]. **(***) F. Alonso-Fernandez**, J. Fierrez, A. Gilperez, J. Galbally, J. Ortega-Garcia, "Robustness of signature verification systems to imitators with increasing skills", *Intl Conf on Document Analysis and Recognition, ICDAR*, Barcelona, Spain, 2009-07-26

Number of citations: 8

[38]. **(***)** V. Ruiz-Albacete, P. Tome-Gonzalez, **F. Alonso-Fernandez**, J. Galbally, J. Fierrez, J. Ortega-Garcia, "Direct attacks using fake images in iris verification", *COST 2101 Workshop on Biometrics and Identity Management, BIOID*, Roskilde University, Denmark, 7-9 May 2008

Number of citations: 60

[39]. **(***)** A. Gilperez, **F. Alonso-Fernandez**, S. Pecharroman, J. Fierrez, J. Ortega-Garcia, "Off-line signature verification using contour features", *Intl Conf on Frontiers in Handwriting Recognition, ICFHR*, Montréal, Québec, August 19-21, 2008 **(Poster)**

Number of citations: 33

[40]. **(***)** P. Tome-Gonzalez, **F. Alonso-Fernandez**, J. Ortega-Garcia, "On the effects of time variability in iris recognition", *Intl Conf on Biometrics: Theory, Apps and Systems, BTAS*, Washington DC, 2008.

Number of citations: 27

[41]. **F. Alonso-Fernandez**, J. Fierrez, D. Ramos J. Ortega-Garcia, "Dealing with sensor interoperability in multi-biometrics: the UPM experience at the BioSecure Multimodal Evaluation 2007", *Defense & Security Symp, Biometric Technologies for Human Identification, BTHI*, Orlando, March 2008. **(Oral)**

Number of citations: 37

[42]. **(**) F. Alonso-Fernandez**, *M. C. Fairhurst*, J. Fierrez J. Ortega-Garcia, "Impact of signature legibility and signature type in off-line signature verification", *IEEE Biometrics Symp, BSYM*, Baltimore, Sept 2007.

Number of citations: 19

[43]. **(**) F. Alonso-Fernandez**, *M. C. Fairhurst*, J. Fierrez, J. Ortega-Garcia, "Automatic measures for predicting performance in off-line signature", *IEEE Intl Conf Image Process., ICIP*, Texas, Sept 2007.

Number of citations: 19

[44]. **(**) F. Alonso-Fernandez**, *F. Roli, G. L. Marcialis*, J. Fierrez, J. Ortega-Garcia, "Comparison of fingerprint quality measures using an optical and a capacitive sensor", *IEEE Conf. on Biometrics: Theory, Applications and Systems, BTAS*, Washington DC, USA, Sept 2007.

Number of citations: 13

[45]. J. Galbally-Herrero, J. Fierrez-Aguilar, J. Rodriguez-Gonzalez, **F. Alonso-Fernandez**, J. Ortega-Garcia and M. Tapiador, "On the vulnerability of fingerprint verification systems to fake fingerprint attacks", in *Proc. IEEE Intl. Carnahan Conf. on Security Technology, ICCST*, pp. 130-136, Lexington, USA, October 2006

Number of citations: 66

Peer-reviewed national (Spanish) conference contributions

(Participation in conference given)

[46]. **(***)** R. Fernandez-de-Sevilla, **F. Alonso-Fernandez**, J. Fierrez, J. Ortega-Garcia, "Identificación Forense de Escritor Usando Características de Emisión Alográfica", *V Jornadas de Reconocimiento Biométrico de Personas, VJRBP10*, Huesca, Spain, September 2010.

[47]. **(***)** P. Tomé González, **F. Alonso Fernández**, J. Ortega García, "Efectos de la Variabilidad Temporal en el Reconocimiento de Iris", *IV Jornadas de Reconocimiento Biométrico de Personas, JRBP08*, Valladolid, Spain, September 2008.

[48]. **(***)** A. Gilpérez, **F. Alonso-Fernandez**, J. Fierrez, J. Ortega-Garcia, "Verificación de firma off-line usando características de contorno", *IV Jornadas de Reconocimiento Biométrico de Personas, JRBP08*, Valladolid, Spain, September 2008.

[49]. **(***)** V. Ruiz-Albacete, P. Tome-Gonzalez, **F. Alonso-Fernandez**, J. Galbally, J. Fierrez, J. Ortega-Garcia, "Ataques directos usando imágenes falsas en verificación de iris", *IV Jornadas de Reconocimiento Biométrico de Personas, JRBP08*, Valladolid, Spain, September 2008.

Number of citations: 3

[50]. J. Galbally, **F. Alonso-Fernandez**, *et al*., "BiosecurID: a Multimodal Biometric Database", in *Proc. MADRINET Workshop*, pp. 68-76, Salamanca, Spain, November 2007. **(Oral)**

Number of citations: 9

[51]. M. Martinez-Diaz, J. Fierrez, J. Galbally, **F. Alonso-Fernandez** and J. Ortega-Garcia, "Signature verification on handheld devices", in *Proc. MADRINET*, pp. 87-95, Salamanca, Spain, Nov 07. **(Oral)**

Number of citations: 1

Review articles, book chapters, books

Authored Books

[52]. **F. Alonso-Fernandez**, "Biometric Sample Quality and its Application to Multimodal Authentication Systems", *PhD Thesis*, Univ. Politecnica Madrid (UPM, Spain), 2008,

http://atvs.ii.uam.es/files/2008_PhDThesis_Alonso.pdf

Number of citations: 15

[53]. J. Ortega García, **F. Alonso Fernández**, *R. Coomonte-Belmonte*, "Seguridad Biométrica" ("Biometrics Security"), *Cuadernos Cátedra ISDEFE-UPM, vol. 3, Fundación Rogelio Segovia para el Desarrollo de las Telecomunicaciones* (Ed.), June 2008, ISBN: 978-84-7402-350-5

Book chapters

[54]. **F. Alonso-Fernandez,** J. Fierrez, J. Bigun, "Quality Measures in Biometric Systems", in *Encyclopedia of Biometrics*, (Stan Z. Li, Ed.), 2nd edition, Springer 2015 (in press)

[55]. **F. Alonso-Fernandez,** J. Fierrez, "Fingerprint Databases and Evaluation", in *Encyclopedia of Biometrics*, (Stan Z. Li, Ed.), 2nd edition, Springer 2015 (in press)

[56]. **(**) F. Alonso-Fernandez**, *J. Bigün*, *et al*., "Fingerprint Recognition", in *Guide to Biometric Reference Systems and Performance Evaluation*, Springer, 2008, ISBN 978-1-84800-291-3

Number of citations: 20

[57]. **(**)** *S. Garcia-Salicetti*, **F. Alonso-Fernandez**, *et al*., "Online Handwritten Signature Verification", in *Guide to Biometric Reference Systems and Performance Evaluation*, Springer, 2008, ISBN 978-1-84800-291-3

Number of citations: 8

[58]. **F. Alonso-Fernandez**, J. Fierrez, "Fingerprint Databases and Evaluation", in *Encyclopedia of Biometrics*, (Stan Z. Li, ed.), Springer 2009, ISBN: 978-0-387-73003-5 (e-Reference)

Open access computer programs or databases

- Database of ground-truth Iris segmentation data
  - Segmentation data of nearly 10000 iris images, in conjunction with Salzburg University (Austria), with the objective of enabling accurate evaluation of iris segmentation algorithms.
  - Described in the publication: *H. Hofbauer*, **F. Alonso-Fernandez**, *P. Wild*, J. Bigun, *A. Uhl*, "A Ground Truth for Iris Segmentation", *Proc. 22nd International Conference on Pattern Recognition*, ICPR, Stockholm, August 24-28, 2014
  - Available at http://islab.hh.se/mediawiki/index.php/Iris_Segmentation_Groundtruth

Popular-scientific articles/presentations and other

Conference contributions without peer-review (participation in conference given)

[59]. **F. Alonso-Fernandez,** J. Bigun, "Biometric Recognition Using Periocular Images", Proc. *Swedish Symposium on Image Analysis, SSBA* (Goteborg), March 14-15 2013 **(Oral)**

[60]. **F. Alonso-Fernandez**, J. Bigun, "Iris Segmentation Using the Generalized Structure Tensor", Proc. *Swedish Symposium on Image Analysis, SSBA* (Stockholm), March 7-9 2012 (**Oral**)

Number of citations: 1

[61]. **F. Alonso-Fernandez**, J. Bigun, "Iris Pupil Detection by Structure Tensor Analysis", Proc. *Swedish Symposium on Image Analysis, SSBA*, (Linköping), March 2011 **(Poster)**

Number of citations: 1

[62]. **F. Alonso-Fernandez**, J. Fierrez, M. Freire, M. Martinez-Diaz, J. Galbally, J. Ortega-Garcia, "ATVS – Biometrics Research Lab, Signature and Handwriting Activities and Perspectives" *COST-2101 Workshop on Signature and Handwriting Analysis for Person Identification* (Canterbury, UK), November 2007. **(Oral, invited presentation)**

[63]. J. Fierrez, **F. Alonso-Fernandez**, D. Ramos, J. Galbally, J. Ortega-Garcia, "Dealing with Sensor

Interoperability using Quality Estimates: The UAM experience at BMEC 2007", in *Proc. NIST Biometric Quality Workshop II*, Gaithersburg, Maryland, USA, Nov. 7-8 2007 (**invited presentation**). Proceedings online www.nist.gov/itl/iad/ig/bio_quality_wkshopii_present.cfm

[64]. N. Poh, T. Bourlai, J. Kittler, A. Salah, **F. Alonso-Fernandez**, J. Baker, H. Ganster, L. Allano, O. Fatukasi, O. Ambekar and T. Scheidat, "A BioSecure (DS2) Report on the Technological Evaluation of Score-level Quality-dependent and Cost-sensitive Multimodal Biometric Performance", in *Final BioSecure Workshop*, Fribourg, Switzerland, 25-27 September 2007 (**Oral**). Available online at http://biometrics.it-sudparis.eu/BMEC2007/files/resultDS2.pdf

[65]. **F. Alonso-Fernandez**, J. Fierrez-Aguilar, H. Fronthaler, K. Kollreider, J. Bigun, J. Ortega-Garcia, "Cutting-edge fingerprint recognition", in *BioSecure Workshop*, Vigo, Spain, 13-15 September 2006 (**Oral**). Presentation available online at http://www.gts.tsc.uvigo.es/BioSecureWorkshop

Popular science articles

[66]. **F. Alonso-Fernandez**, "It is written all over your face", Center for Applied Intelligent Systems (CAISR) Research Profile, Halmstad University (Sweden), Annual Report 2014, published March 2015, http://islab.hh.se/mediawiki/CAISR_Annual_report_2014

[67]. J. Bigun, **F. Alonso-Fernandez**, S. M. Karlsson, A. Mikaelyan, "Identity and Message recognition by biometric signals", Center for Applied Intelligent Systems (CAISR) Research Profile, Annual Report 2012, April 2013

www.hh.se/download/18.149d6d3d13e19db3d27b58/1366797108619/CAISRarsrapport2012.pdf

Research documents and reports *(Halmstad University)*

[68]. **F. Alonso-Fernandez**, J. Bigun, "Halmstad University submission to the First ICB Competition on Iris Recognition (ICIR2013)", Technical Report, Halmstad University, August 2013, http://hh.diva-portal.org/smash/record.jsf?searchId=1&pid=diva2:643009

Research documents and reports *(FP6 IST-2002-507634, BioSecure NoE Deliverables)*

[69]. J. Ortega-Garcia, **F. Alonso-Fernandez**, J. Fierrez-Aguilar, *et al*., "BioSecure application oriented multimodal biometric database", in *Deliverable D.6.3.1*, July 2007

[70]. *R. Veldhuis*, **F. Alonso-Fernandez**, *et al*., "Final report on the jointly executed research carried out on fingerprint modality", in *Deliverable D.7.3.4*, July 2007

[71]. *L. Allano*, **F. Alonso-Fernandez**, J.L. Alba-Castro, G. Chollet, B. Dorizzi and A. Mayoue, "Biosecure validated data sets", in *Deliverable D.6.4.1*, July 2007

(7 more reports produced before 2007)

Invited Talks at Conferences and Workshops (as speaker)

- A. Mikaelyan, **F. Alonso-Fernandez**, J. Bigun, "Periocular Recognition by Detection of Local Symmetry Patterns", *Workshop on Insight on Eye Biometrics*, IEB, in conjunction with the *Intl Conf on Signal Image Technology & Internet Based Systems*, SITIS, Marrakech, Morocco, 23-27, Nov 2014 (**presenting an invited paper**)
- **F. Alonso-Fernandez,** J. Bigun, S. Karlsson, A. Mikaelyan, "Personal recognition based on facial information", *Workshop of the Norwegian Biometric Forum* (NBF), in cooperation with the Norwegian Forum for Research and Innovation in Security and Communications (FRISC network) and the European Association for Biometrics (EAB), Oslo, Norway, November 14, 2013 (**invitation to talk about own research**), http://eab.org/events/program/43

- **F. Alonso-Fernandez**, J. Fierrez, A. Gilperez, J. Ortega-Garcia, "Impact of time variability in off-line writer identification and verification", *ISPA conference, Special Session. on Signal and Image Processing for Biometrics*, Salzburg, Austria, September 16, 2009 (**presenting an invited paper**)
- **F. Alonso-Fernandez**, J. Fierrez, M. Freire, M. Martinez-Diaz, J. Galbally, J. Ortega-Garcia, "ATVS – Biometrics Research Lab, Signature and Handwriting Activities and Perspectives" *COST-2101 Workshop on Signature and Handwriting Analysis for Person Identification* (Canterbury, UK), November 2007 (**invitation to talk about own research**)

Invited Talks at Conferences and Workshops (as co-author)

- J. Fierrez, **F. Alonso-Fernandez**, D. Ramos, J. Galbally, J. Ortega-Garcia, "Dealing with Sensor Interoperability using Quality Estimates: The UAM experience at BMEC 2007", *Proc. NIST Biometric Quality Workshop II*, Gaithersburg, USA, Nov. 7-8 2007 (**invited presentation about own research**). Proceedings online at www.nist.gov/itl/iad/ig/bio_quality_wkshopii_present.cfm

Other Research Talks and Presentations *(Halmstad University, CAISR project meetings and others)*

- **F. Alonso-Fernandez**, "Personal Detection and Recognition Based on Facial Information", *CAISR Reference Group and Industrial Advisory Board Workshop*, presentation of own research activities to the Reference Group (group of 6 people from industry and academia, acting as external evaluators of the activities within the project) and to the industrial partners of the CAISR project, 20th – 21st August 2013 (**poster**)
- **F. Alonso-Fernandez**, "Facial Detection and Recognition Resilient to Physical Image Deformations", *CAISR Industrial Advisory Board Workshop*, presentation of own research activities to the industrial partners of the CAISR project (8 companies), 4th February 2013 (**talk and poster**)
- **F. Alonso-Fernandez**, J. Bigun, S. Karlsson, A. Mikaelyan, "Signal Analysis Area. Basic Research and Applications", *CAISR Reference Group Workshop*, presentation of own research activities to the Reference Group of the CAISR project (group of 6 people from industry and academia, acting as external evaluators of the activities within the project), 20th June 2012 (**talk**)
- **F. Alonso-Fernandez**, "Iris-Based Person Authentication", presentation of own research and state of the art, meeting at Halmstad University with representatives of the *Swedish National Laboratory of Forensic Science*, SKL, 27 Sept. 2011 (**talk**)

Seminars

- **F. Alonso-Fernandez**, "Biometric Systems", Postgraduate course on Forensic Sciences, Madrid, Spain, November 17 and 19, 2009
- **F. Alonso-Fernandez**, "Biometric Systems", Postgraduate course on Forensic Sciences, Madrid, Spain, November 11, 2008
- **F. Alonso-Fernandez**, "Signal Sampling and Reconstruction", Graduate Seminar at the Biometrics Research Lab.- ATVS, Madrid, Spain, May 14, 2008
- **F. Alonso-Fernandez**, "Interpolation and Decimation of Signals", Graduate Seminar at the Biometrics Research Lab.- ATVS, Madrid, Spain, May 14, 2008
- **F. Alonso-Fernandez**, "The Discrete Fourier Transform", Graduate Seminar at the Biometrics Research Lab.- ATVS, Madrid, Spain, May 13, 2008

- **F. Alonso-Fernandez**, "Discrete Signals and Systems", Graduate Seminar at the Biometrics Research Lab.- ATVS, Madrid, Spain, May 12, 2008
- **F. Alonso-Fernandez**, "Linear-Time Invariant Systems", Graduate Seminar at the Biometrics Research Lab.- ATVS, Madrid, Spain, May 12, 2008
- **F. Alonso-Fernandez**, "Biometric Systems", "Communications Protection" and "Cryptography", Postgraduate course on Security Management, MAPFRE University Foundation, Madrid, Spain, November-December 2007
- **F. Alonso-Fernandez**, "Biometric Systems", Postgraduate course on Forensic Sciences, Madrid, Spain, October 31 and November 5, 2007

CV

Name: Josef Bigun	**Doctorial degree:** 1988-05-06
Birthdate: 19610108	**Academic title:** Professor
Gender: Male	**Employer:** Högskolan i Halmstad

Research education

Dissertation title (swe)
Lokala symmetri egenskaperi bildbehandling

Dissertation title (en)
Local symmetry features in image processing

Organisation	Unit	Supervisor
Linköpings universitet, Sweden Sweden - Higher education Institutes	Institutionen för systemteknik (ISY)	Gösta Granlund

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20205. Signalbehandling		1988-05-06

CV

Name: Fernando Alonso-Fernandez	**Doctorial degree:** 2008-10-01
Birthdate: 19780531	**Academic title:** Doktor
Gender: Male	**Employer:** Högskolan i Halmstad

Research education

Dissertation title (swe)
Biometric Sample Quality and its Application to Multimodal Authentication Systems

Dissertation title (en)
Biometric Sample Quality and its Application to Multimodal Authentication Systems

Organisation	Unit	Supervisor
Universidad Politecnica Madrid, Spain Not Sweden - Higher Education institutes		Javier Ortega-Garcia

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20205. Signalbehandling		2008-10-01

Publications

Name: Josef Bigun	**Doctorial degree:** 1988-05-06
Birthdate: 19610108	**Academic title:** Professor
Gender: Male	**Employer:** Högskolan i Halmstad

Bigun, Josef has not added any publications to the application.

Publications

Name: Fernando Alonso-Fernandez	**Doctorial degree:** 2008-10-01
Birthdate: 19780531	**Academic title:** Doktor
Gender: Male	**Employer:** Högskolan i Halmstad

Alonso-Fernandez, Fernando has not added any publications to the application.

Register

Terms and conditions

The application must be signed by the applicant as well as the authorised representative of the administrating organisation. The representative is normally the department head of the institution where the research is to be conducted, but may in some instances be e.g. the vice-chancellor. This is specified in the call for proposals.

The signature*from the applicant*confirms that:

- the information in the application is correct and according to the instructions form the Swedish Research Council
- any additional professional activities or commercial ties have been reported to the administrating organisation, and that no conflicts have arisen that would conflict with good research practice
- that the necessary permits and approvals are in place at the start of the project e.g. regarding ethical review.

The signature *from the administrating organisation* confirms that:

- the research, employment and equipment indicated will be accommodated in the institution during the time, and to the extent, described in the application
- the institution approves the cost-estimate in the application
- the research is conducted according to Swedish legislation.

The above-mentioned points must have been discussed between the parties before the representative of the administrating organisation approves and signs the application.

Project out lines are not signed by the administrating organisation. The administrating organisation only sign the application if the project outline is accepted for step two.

Applications with an organisation as applicant is automatically signed when the application is registered.