1. FINAL PUBLISHABLE SUMMARY REPORT for IRG 239494

1.1. Comprehensive Summary

Humans can effortlessly visually sense dynamic physical properties such as viscosity, elasticity, or stiffness and optical properties of materials such as transparency, glossiness, shininess, or roughness. Many critical perceptual judgments, from telling whether fruit is ripe to determining whether the ground is slippery, involve visually estimating such material properties. Yet, very little is known about how the brain recognizes materials, even though the problem is likely as important for survival as navigating or recognizing objects (Figure 1).

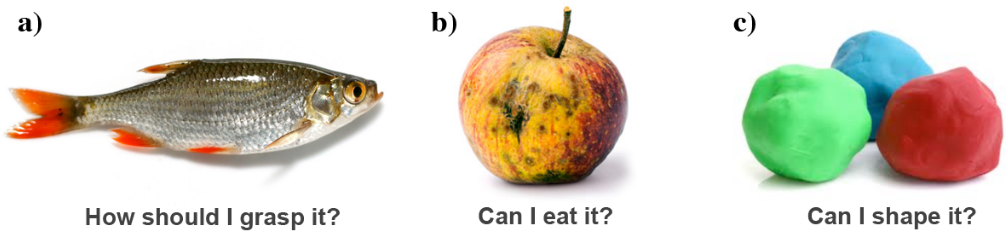

Figure 1. Correctly judging material qualities is crucial. The ability to visually sense dynamic physical and optical properties are critical for a wide range of tasks that we do every day. For example deciding how to grasp something (a), whether something is edible (b), whether something is pliable (c).

To fully understand how conscious experience of material quality can arise it is necessary to both, understand what information the visual system extracts from the inherently ambiguous retinal input, and how this information is processed by the brain. The aim of project VISMA (Figure 2) has been to advance the study of human visual perception of surface material qualities, by focusing on the identification of environmental cues signaling surface material quality and by deciphering the neural processes by which surface material perception is mediated. A particular novel aspect of the work has been the focus on dynamic cues to material perception, in particular exploring the non-obvious question whether and how image motion can convey optical properties of surface material.

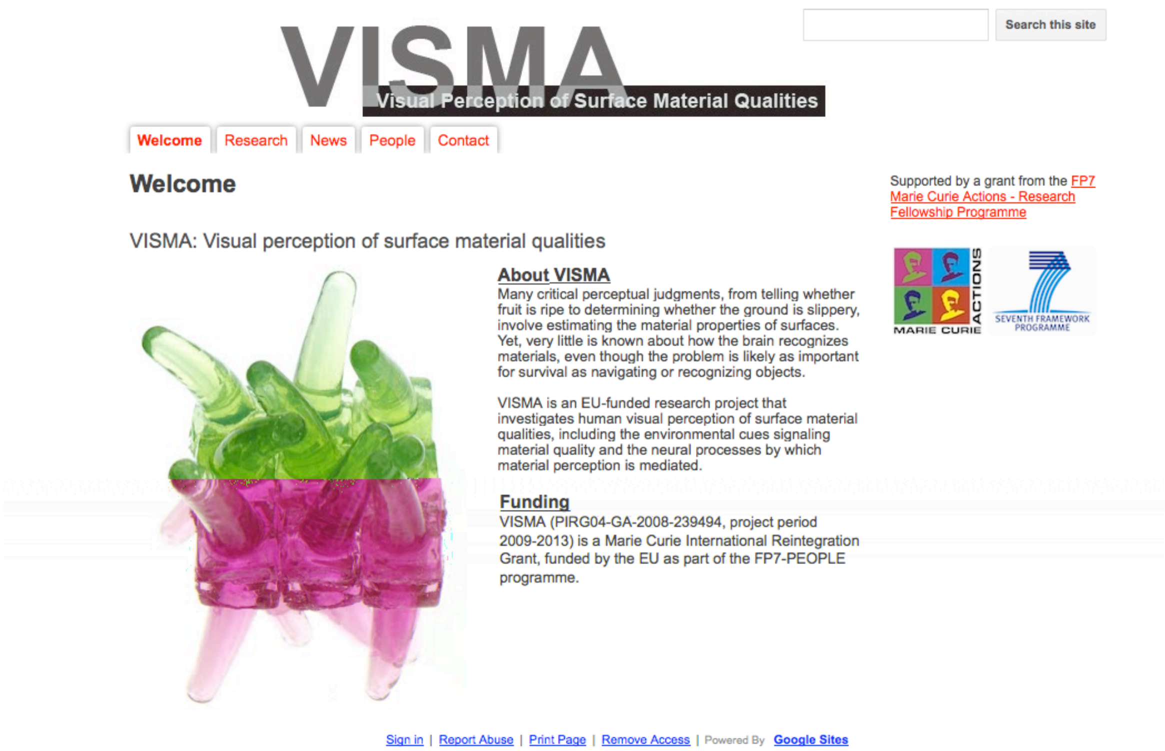

Figure 2. Project "Material Perception" (VISMA). Screen shot of the project website.

1.2. Overview of Results

Combining behavioral, computational and neuroimaging methods the most significant results have been the discovery of a previously unknown use for optic flow in the perception of surface material properties (Figure 3), the utilization of this newly identified source of information in a machine algorithm that successfully detects and localizes specularities in natural scenes (Figure 4), and a demonstration of neural adaptation to optic flow-based surface reflectance properties. Substantial progress has also been made in the identification of cortical areas that are involved in the processing of optic flow-based optical material qualities. These and related findings have resulted in journal papers that have been published or are under review in journals such as Current Biology, Pattern Recognition, Journal of Vision, or Machine Vision and Applications.

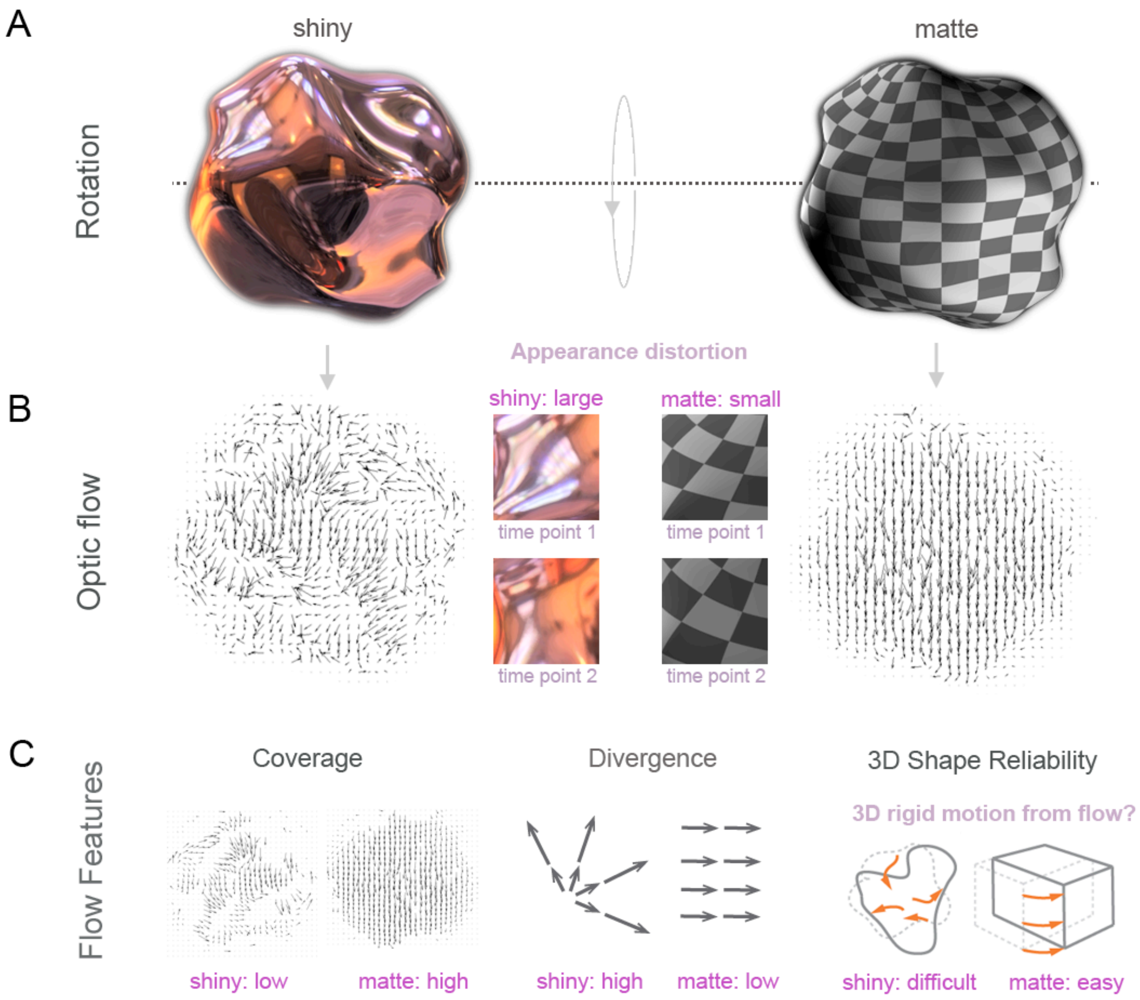

Figure 3. From Illustration of the three flow features. (a) A complex shiny (left) and matte, textured object (right) are rotating about the horizontal axis, front downwards towards the observer. (b) This rotation gives rise to distinct flow pattern for each surface material. The shiny object exhibits a marked amount of *appearance distortion*, i.e. feature absorption and genesis, whereas the appearance of the matte object does not change substantially. (c) Three flow features arise from this characteristic appearance distortion: 1. Coverage, 2. Divergence, 3. 3D Shape Reliability. Reprinted with permission from Doerschner et al. (2011) Copyright © 2011 by Elsevier Inc)

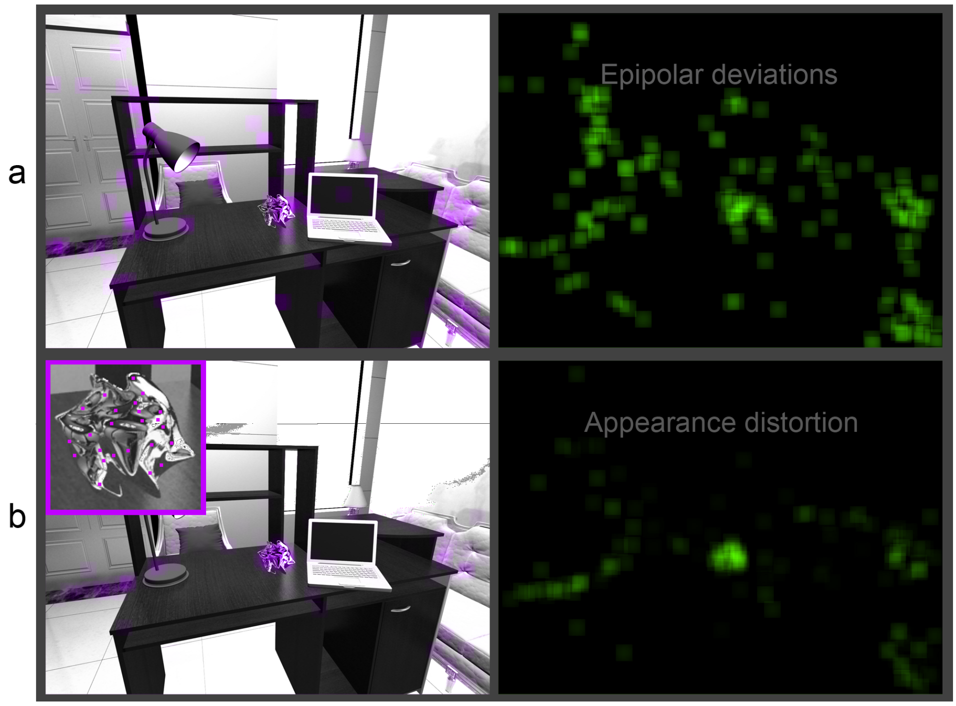

Figure 4. A specularity detection algorithm. We developed an algorithm that detects specularities based on appearance distortion, a visual feature that has been identified in our work on the human visual system. A sample frame from the image sequences we used in our experiments with state of the art detection algorithm (a), and our proposed algorithm (b) overlaid in purple, and in green on the right. The specular object is located on the desk. Inset figure in (b) illustrates that unlike previous approaches appearance distortion also detects concave specular regions. Adapted from Yilmaz & Doerschner, (Under Review, MVA).

1.3. Conclusion

Taken together the project has been completed successfully meeting all major milestones and deliverables as outlined in the work plan of Part B (Table2). The research conducted has lead to publications in respected international journals, and to new local, national, and international collaborations. Thus, the researcher has been successfully integrated into the national and European Research Area.

A research project frequently ends with more questions than it started out with, and also here, there is more work that remains to be done to "unravel the mysteries of perception". In a newly EU funded research and training network, that is coordinated by Roland Fleming at the University of Giessen, and of which Bilkent University and Dr. Doerschner are full partner, these questions will continue to be pursued (PRISM: perceptual representation of illumination shape & material, https://sites.google.com/site/prismitn).

In addition to visual material perception, Dr. Doerschner has been involved in a line of research that has developed during the project period and with project support: a research initiative combining genomic and neuroimaging analyses to understand brain development, structure and function, by studying patients with single-gene mutations that affect cortical development. This work has lead to several publications, e.g. in Nature Genetics, and Genome Research (also see https://sites.google.com/site/pomirg/research), and has recently resulted in a nationally (TUBITAK) funded project, lead by Dr. Doerschner, investigating visual behavior in a patient with congenital cortical pachygyria. This project has high potential impact as it may reveal the link(s) between single gene, cortical structure, function and visual behavior.

For her accomplishments and her multi-methodological approach in studying the development structure and function of the human visual system Dr. Doerschner has been recognized in 2012 and 2013 with two prestigious national Young Scientist Awards (the Scientific and Technological Research Council of Turkey (TUBITAK) "Young Scientist Encouragement Award" and the Turkish Academy of Sciences (TUBA) "Outstanding Young Scientist Award", respectively).

1.4. Socio-Economic Impact

The scope of this basic research project lies in the general area of cognitive neuroscience. As such, the broader goal is to achieve a scientific understanding of how the mind perceives, thinks, and acts. It is expected that this understanding will ultimately have a "revolutionary impact on national interests in science, medicine, economic growth, security, and well-being" (Akil et al., Science, 2010). Moreover, the research conducted in the scope of this project sparked new collaborations and attracted additional national and international funding, thus creating new jobs, advancing scientific excellence by training young researchers, and ultimately reversing the brain drain by increasing the visibility of Turkey and Europe as a place to conduct cutting edge research.