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Microwave Sensing and Imaging in Health and Food Industry

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Microwave sensing and imaging is a technology able to exploit differences in dielectric properties of objects illuminated with an array of antennas/sensors at low-power microwave frequencies [1]. It has several attractive characteristics such as it is non-destructive, contactless, totally safe for operators, potentially real-time, cost-efficient and easy to operate. On the other side, there are some intrinsic constraints. Obviously, a dielectric contrast has to be present, in the considered frequency range, between the part of the object to be identified and the surrounding media. Moreover, the achievable spatial resolution and penetration depth, of the electromagnetic wave within the object under test, have opposite requirements on the optimal working frequency of designed microwave system.

Here, the key ingredients to design, model, realize and validate a microwave imaging system are investigated. They include the development of an ad-hoc problem-based design procedure as well as a reliable and effective forward solver, together with model-based imaging techniques, implemented on specialized hardware.
Then, two real-world applications are analyzed in details: quality control in food industry in order to detect foreign bodies contamination in packaged products [2][3], and medical diagnostic for the continuous monitoring of patients after the stroke onset [4][5].

Detection of foreign bodies, such as plastic or glass fragments, in food or beverage products, is still an open issue and it can generate costumers' complaint against food manufacturers, loss of brand loyalty and large recall expenses. The microwave imaging system, discussed here, has been designed to perform in-line monitoring of food products along the packaging conveyor belt. Hence, fast measurements are guarantee, due to the high velocity of the belt, with aspect-limited measurements, because all the products move along a row.

In medical diagnostics, imaging methodologies are a great support to the clinician. Here, the application of microwave imaging techniques is focused on the continuous monitoring of patients in the stroke post-acute stage, in a complementary fashion with other well-established techniques, such as computerized tomography and magnetic resonant imaging. The proposed microwave device has been designed through a rigorous procedure based on the singular value decomposition of the discretized scattered operator [6], in order to choose the proper working frequency range and matching medium as well as the optimized antenna array placement.

Finally, for both applications, the experimental testing of the realized prototypal microwave devices is presented and discussed.

References

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