FURTHER READING

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'Comparison of clutter rejection techniques for measurement of small displacements of body surface using radar'
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Comparing methods of isolating vital signs in a cluttered environment

vital measurements

Using Doppler radar techniques to monitor medical patients is a rapidly growing field with great potential. Authors from Kyoto University, University of Hyogo, and the Advanced Research Division of the Panasonic Corporation, Japan, have compared three promising techniques for clutter rejection when measuring small displacements in a patient's body. In this article we explore their motivation for, and the background of this important research.

Look, don't touch

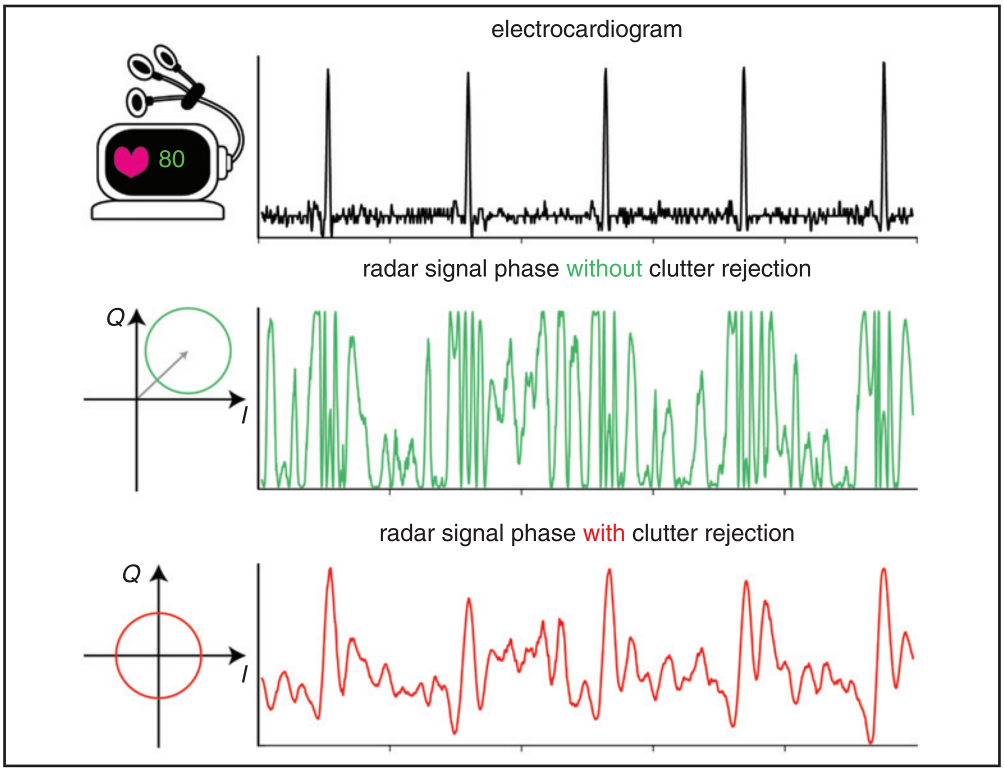
Measuring a patient's vital signs vital in medical situations. The ability to accurately detect and record a patient's cardiopulmonary details (information relating to the heart and lungs) can be a matter of life and death, particularly in situations requiring round the clock observation. This, however, can be problematic in situations where either a patient must not be moved, perhaps not even be touched at all, or where they must retain the ability to move freely. The solution: non-contact measurement systems. These allow medical staff to monitor their patients without needing to attach equipment directly to them.

Doppler radar is one method of achieving this. These systems detect the phases of reflected electromagnetic (EM) waves which are disturbed by displacement of the patient's skin. At high operating frequencies even tiny displacements can be detected, allowing the system to recognise small changes in cardiopulmonary activities. A major benefit of this technology is that it is sensitive enough to monitor the extremities, rather than just the torso. As an additional advantage, at microwave frequencies Doppler radar can penetrate clothing, and, perhaps more importantly, thick bandages.

Cleaning up the clutter

Unfortunately, the electromagnetic waves from the radar system can also reflect off other objects in the patient's vicinity, such as the walls, floor or furniture. These "clutter signals" can contaminate those from the patient's vital signs. The more objects, the higher the clutter power. "If the radar uses a wide frequency band, many clutter signals can be rejected simply by performing a time-gating operation in the time domain. However, many low-cost non-contact vital sign monitoring devices use a continuous wave or a narrow frequency band, and thus, suffer from large clutter power" explain the authors. These signals need to be removed or compensated for in order to extract useful information.

As most clutter objects are stationary, they do not cause the phase changes associated with the Doppler Effect. These echoes share the same frequency as the emitted signal. As a result, when down-converted by the receiver into a complex baseband, they appear as a direct current (DC) component in the demodulated signal data. On the other hand, whilst the echo phase is sensitive to small displacements in the patient, the echo power is near constant. This causes the signals containing information about vital signs to move along a circle in the I-Q plane (a complex plane displaying the phase and amplitude of the received electromagnetic waves). The static clutter signals in contrast, appear at the centre of such circles. In their Letter, the authors looked at three existing techniques to discover which performs best when attempting to estimate the centre of the circle formed by the complex signal data in the I-Q plane.



TOP: The effect of the clutter rejection on a received signal
BOTTOM: A mock set up with a seated subject

"We expect our findings will help numerous researchers worldwide who are working on non-contact vital sign monitoring technologies" the authors told us. "Even if a signal contains multiple vital signs, the clutter rejection technique can be used before or after the separation of the multiple signals. This is why centre estimation technique is essential in this field." The authors hope that the technique they found to perform the best is included in future non-contact vital sign measurement technologies.

As this develops, future systems should be able to differentiate between echoes received simultaneously from multiple individuals. Unfortunately, this stops the data from exhibiting the circle in the IQ plane, requiring a new technique capable of separating the signal for each individual before or after clutter rejection. If this is accomplished, the authors believe these systems have potential applications monitoring babies and the elderly, where freedom of movement is a necessity. "This technology will improve safety and comfort in society" the authors said.