LIST OF FIGURE

2.1 Signals obtained from respiratory activity. (Source: H. Hamdi, dkk., Emotion assessment for affective computing based on physiological responses, 2012) 8
2.2 Block diagram of radar systems in general. 9
2.3 The working principle of radar. 9
2.4 The FMCW radar waveform. 11
2.5 The FFT signal path to range-doppler frame. 12
2.6 Diagram of FMCW radar system for respiration detection. 13
2.7 Illustration of the radar wave propagation. 14
2.8 The block diagram of FMCW radar system to detect human respiration behind the wall. 15
2.9 The illustration of A-scan. 18
2.10 The illustration of B-scan. 19
2.11 The illustration of C-scan. 19

3.1 The radar FMCW 24 GHz. 31
3.2 The illustration of the laboratory experiment setup. 31
3.3 Measurement of the first scenario. 32
3.4 Measurement second scenario. 32
3.5 Measurement third scenario. 33
3.6 The workflow to detect human respiration under rubble. 36
3.7 Magnitude response of LPF output in the frequency domain when the target is laid down under rubble with other objects. 37
3.8 Time domain representation of phase detector output in ROI. 38
3.9 Frequency domain representation of phase detector output in ROI. . 39

4.1 The magnitude response of LPF output in the frequency domain. . . 43
4.2 Phase detector output for each FFT index ROI in time domain representation. 44
4.3 Phase detector output for each FFT index ROI in frequency domain representation. 44
4.4 Phase detector output comparison between with and without a target in the time domain for the first scenario. 45

4.5 Phase detector output comparison between with and without a target in the frequency domain for the first scenario. 46
4.6 Magnitude response of LPF output comparison between with and without a target in the frequency domain for the first scenario. . . . 47
4.7 Comparison of the magnitude response in the frequency domain for different concrete brick thicknesses. 48
4.8 The phase detection result obtained several points in the first scenario. 49
4.9 B-scan image for the first scenario. (a) With target. (b) Without target. 50
4.10 The Weighting process method to reduce clutter in the first scenario. 51
4.11 The Eigen 1 of SVD method to reduce clutter in the first scenario. . 52
4.12 The LTS method to reduce clutter in the first scenario. 54

B.1 The magnitude response of LPF output in the frequency domain for the second scenario. . . . . .
B.2 Comparison of the magnitude response in the frequency domain for the second scenario. . . . . .
B.3 The magnitude response of LPF output in the frequency domain for the third scenario. . . . . .
B.4 Comparison of the magnitude response in the frequency domain for the third scenario. . . . . .

C.1 Phase detector output in the time domain using BPF. . . . . .
C.2 Phase detector output in the frequency domain using BPF. . . . . .
C.3 Phase detector output for each FFT index ROI in time domain representation in the second scenario. . . . . .
C.4 Phase detector output for each FFT index ROI in frequency domain representation in the second scenario. . . . . .
C.5 Comparison of phase detector output in the time domain in the second scenario. . . . . .
C.6 Comparison of phase detector output in the frequency domain in the second scenario. . . . . .
C.7 Phase detector output for each FFT index ROI in time domain representation in the third scenario. . . . . .
C.8 Phase detector output for each FFT index ROI in frequency domain representation in the third scenario. . . . . .
C.9 Comparison of phase detector output in the time domain in the third scenario. . . . . .

C.10 Comparison of phase detector output in the frequency domain in the third scenario. . . . . .
C.11 The phase detection result obtained several points in the second scenario. . . . . .
C.12 The phase detection result obtained several points in the third scenario.

D.1 B-scan image for the second scenario. (a) With target. (b) Without target. . . . . .
D.2 B-scan image for the third scenario. (a) With target. (b) Without target. . . . . .
D.3 The Weighting process method to reduce clutter in the second scenario. . . . . .
D.4 The Eigen 1 of SVD method to reduce clutter in the second scenario.
D.5 The LTS method to reduce clutter in the second scenario. . . . . .
D.6 The Weighting process method to reduce clutter in the third scenario.
D.7 The Eigen 1 of SVD method to reduce clutter in the third scenario. .
D.8 The LTS method to reduce clutter in the third scenario. . . . . .
D.9 The Eigen 2 of SVD method to reduce clutter in the first scenario. .
D.10 The Eigen 3 of SVD method to reduce clutter in the first scenario. .
D.11 The Eigen 2 of SVD method to reduce clutter in the second scenario.
D.12 The Eigen 3 of SVD method to reduce clutter in the second scenario.
D.13 The Eigen 2 of SVD method to reduce clutter in the third scenario. .
D.14 The Eigen 3 of SVD method to reduce clutter in the third scenario. .