# On the derivation of vectorcardiographic parameters in continuous ECG monitoring applications

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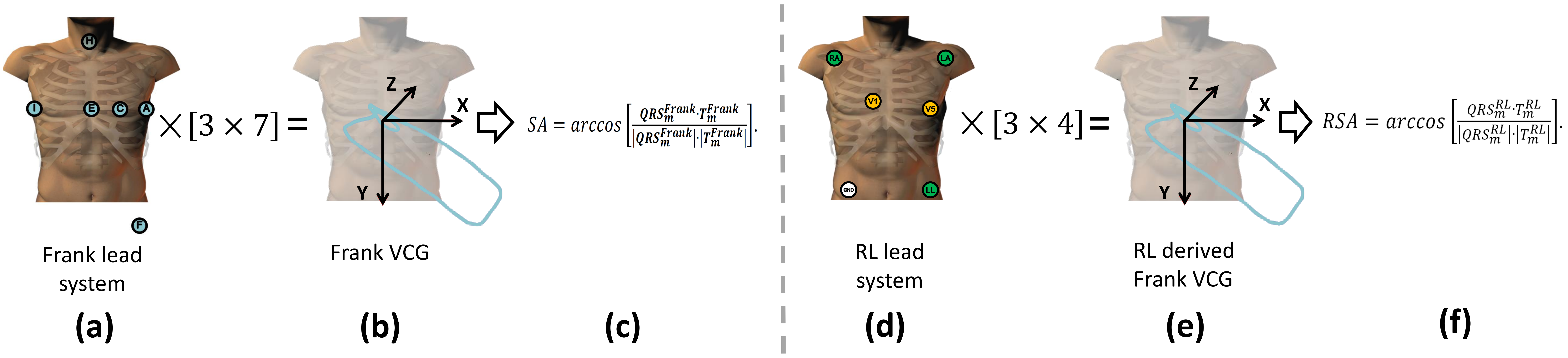
## Introduction.

The spatial QRS-T angle (SA) has been identified as a marker for changes in the ventricular depolarization and repolarization sequence [1]. The determination of the SA requires vectorcardiographic (VCG) data. However, VCG data is seldom recorded in monitoring applications [2]. This is mainly due to the fact that the number and location of the electrodes required for recording the Frank VCG complicate the recording of VCG data in monitoring applications. Alternatively, reduced lead systems (RLS) allow for the derivation of the Frank VCG from a reduced number of electrocardiographic (ECG) leads. Derived Frank VCGs provide a practical means for the determination of the SA in monitoring applications. One widely studied RLS that is used in clinical practice is based upon Mason-Likar leads I, II, V1 and V5 (RL) [3]. The aim of this research was two-fold. First, to develop a linear ECG lead transformation matrix that allows for the derivation of the Frank VCG from the RL system. Second, to assess the accuracy of the RL derived SA (RSA).



$$\times[3\times 7]=$$

$$SA = arccos\left[\frac{QRS_m^{Frank}\cdot T_m^{Frank}}{\left|QRS_m^{Frank}\right|\cdot\left|T_m^{Frank}\right|}\right].$$

$$\times[3\times 4]=$$

$$RSA = arccos\left[\frac{QRS_m^{RL}\cdot T_m^{RL}}{\left|QRS_m^{RL}\right|\cdot\left|T_m^{RL}\right|}\right].$$

Figure 1. Derivation of the SA and the RSA. (a) Electrode locations of the Frank lead system. (b) Derivation of the Frank VCG. (c) Calculation of SA using the Frank VCG. (d) Electrode locations of the RL lead system. (e) Computation of the RL derived Frank VCG. (e) Calculation of RSA using the RL derived Frank VCG.

## Material and Methods.

We used ECG data recorded from 545 subjects for the development of the linear ECG lead transformation matrix. The accuracy of the RSA was assessed by analysing the differences between the RSA and the SA using the ECG data of 181 subjects. The differences between the RSA and the SA were quantified as systematic error (mean difference) and random error (span of Bland-Altman 95% limits of agreement).

## Results.

The systematic error [ $mean(\Delta SA)$ ] between the RSA and the SA was found to be 4.17° [95% confidence interval: 1.74° to 6.61°]. The random error was quantified as 65.09° [95% confidence interval: 57.39° to 75.85°].

The histogram and the maximum likelihood normal distributional fit of the differences $\Delta SA$ (between SA and RSA) in Figure 2 (a) suggests a normal distribution for the $\Delta SA$ values.

The Bland-Altman plot in Figure 2 (b) suggests a constant magnitude of the random error component $[2\cdot 1.96\cdot std(\Delta SA))]$ across the codomain the SA.

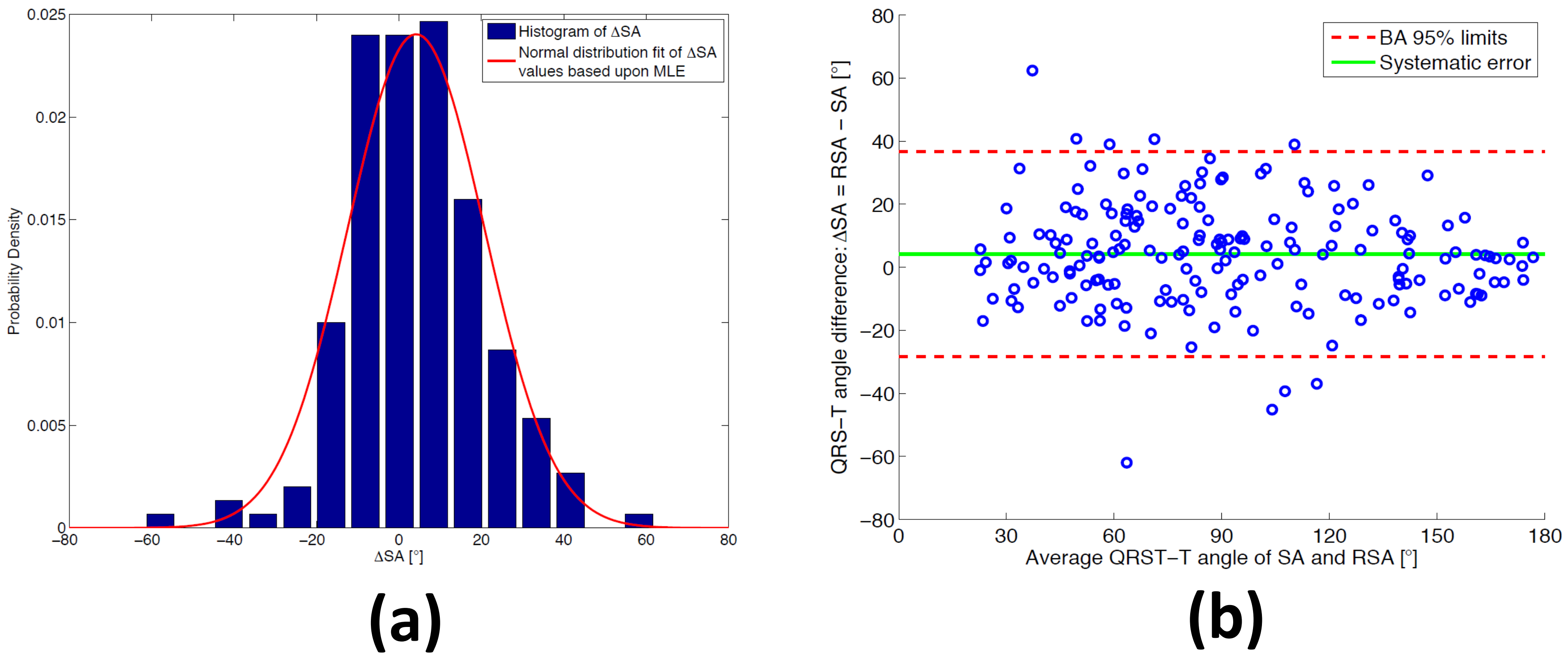


Figure 2. Distribution of the differences between RSA and SA. (a) Histogram and maximum likelihood normal distribution fit of the differences between RSA and SA. (b) Bland-Altman plot of the differences between RSA and SA over the average angle between RSA and SA.

## Conclusion.

The findings of this research suggest that both systematic and random error can not be overlooked when using the RSA as a substitute for the SA.

### References.

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[3] Schreurs CA, et al. "The spatial QRS-T angle in the Frank vectorcardiogram: Accuracy of estimates derived from the 12-lead electrocardiogram," J *Electrocardiol*, vol. 43, pp. 294-301, 2010.

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