Extended Multiple Linear Regression in the Derivation of Electrocardiographic Leads

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In this study, we investigate the performance of an approach for deriving electrocardiographic leads with the aim of improving derivation accuracy. We focus our attention on a limited lead system that uses leads I, II, V2 and V5 to derive the remaining precordial leads. Our extended multiple linear regression based lead transformation approach (EMLRLT) extends the standard multiple linear regression (MLR) approach by combining the data from the recorded leads with quadratic and cross product terms from the same leads. The study dataset consisted of 180 12-lead ECGs extracted from the PTB Diagnostic ECG Database (publicly available via PhysioNet). A computerized algorithm was used to identify QRSonset, QRSoffset and T-end. Patient specific lead transformations for the standard MLR and EMLRLT approaches were calculated via multiple linear regression analysis. In both approaches, 50 QRST complexes from each recording were used to develop the transformations. Subsequently, data from 50 unseen complexes were used to compare estimation accuracy of both approaches. Median RMS error values were calculated for QRS complexes, ST-T segments and for the entire QRST. It was found that all missing leads were more accurately estimated using the EMLRLT approach. Using the standard MLR, the median RMSEs for the QRST were found to be 44.2V, 42.7V, 40.3V and 19.3V for leads V1, V3, V4 and V6, respectively. Using the EMLRLT approach, the median RMSEs for the QRST were found to be 28.2V, 29.3V, 25.1V and 13.4V for leads V1, V3, V4 and V6, respectively. According to the sign test, all differences were statistically significant with $p<0.05$. This study has demonstrated that alternative methods for lead transformation have the potential to improve lead derivation accuracy. Further research is required in order to assess whether or not these improved performance metrics translate into an improved diagnostic accuracy.