Countdown to physician-free EKG interpretation

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Funding Acknowledgement: Type of funding source: None

Background: With the introduction of electronic medical records and other digital platforms, the classification and coding of different medical entities have become a complex, cumbersome task that is prone to diagnostic inconsistencies and errors. By incorporating Artificial Intelligence (AI) to a massive database of EKG records, we have developed an innovative methodology to accurately discriminate an EKG as "normal" or "abnormal". We firmly believe that this algorithm sets up medicine on a path of complete computer-aided EKG interpretation.

Purpose: To present a viable AI-guided filter that can accurately discriminate between normal and abnormal EKG within a cardiologist-annotated EKG database.

Methods: An observational, retrospective, case-control study. Samples: A total of 140,000 randomly sampled 12-lead ECG of 10-seconds length with a sampling frequency of 500 [Hz] from Brazil (BR) and Colombia (CO) (divided as 70,000 normal and 70,000 abnormal EKG records per country dataset) were derived from the private International Telemedical System (ITMS) database from September 2018 to July 2019. Only de-identified records were used, records with artifacts were excluded. Preprocessing: Only the first 2s of each short lead and 9s of the long lead were considered. This data includes mobile (MOB) and transtelephonic (TTP) EKGs (50/50 ratio). Limb leads I, II and III and precordial leads V1, V2, V3 and V5 were used. The mean was removed from each lead. Training Sets: Four models were trained as depicted in the figure below. Each training dataset has 25,000 Normal and 25,000 Abnormal records, where 10% of the total records were used as a validation set. The test sets included 10,000 normal, and 10,000 abnormal records each. Testing and Class Assigning: An inception convolutional neural network was implemented; Each model was tested with 5,000 normal and 5,000 abnormal records of the corresponding country and transmission type with which they were trained. "Normal" or "Abnormal" labels were assigned to each EKG record and were compared to the cardiologists' reports; performance indicators (accuracy, sensitivity, and specificity) were calculated for each model.

Results: An overall accuracy of 82.4%; sensitivity of 88.7%; and specificity of 76.2% was achieved amongst the 4 testing models (Separate results of each training set are shown below).

Conclusion(s): AI enables the interpretation of digital EKG records to be exercised in an organized, accurate, and straightforward manner, taking into consideration the multiple potential entities that can be diagnosed through this historical triage tool. By quickly identifying the normal records, the cardiologist is able to invest efforts in treating patients in a timely manner.

A. Data Set

Model	Training Set		Testing Set	
	Abnormal	Normal	Abnormal	Normal
ITMS BR MOB	25,000	25,000	10,000	10,000
ITMS BR TTP	25,000	25,000	10,000	10,000
ITMS CO MOB	25,000	25,000	10,000	10,000
ITMS CO TTP	25,000	25,000	10,000	10,000
Total EKG's	1,00,000	1,00,000	40,000	40,000

Abnormal EKG's Included - Ventricular and Supraventricular Arrhythmias, Conduction abnormalities, Axis deviation, Chamber enlargement/hypertrophy, ST-T Changes

B. Individual Model Results

		CARDIOLOGIST EKG ANNOTATIONS (Ground Truth)							
		BR-MOB model		BR-TTP model		CO-MOB model		CO-TTP model	
		Abnormal (+)	Normal (-)	Abnormal (+)	Normal (-)	Abnormal (+)	Normal (-)	Abnormal (+)	Normal (-)
AI Output	Abnormal (+)	8,934	2,072	9,148	2,180	9,213	2,469	8,166	2,782
	Normal (-)	1,066	7,928	852	7,820	787	7,531	1,834	7,218
	Total EKG's	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Results (%)	Accuracy	84.30		84.84		83.72		76.92	
	Sensitivity (Abn)	89.34		91.48		92.13		81.66	
	Specificity (Nor)	79.30		78.20		75.31		72.18	

C. Overall Results

		CARDIOLOGIST EKG ANNOTATIONS (Ground Truth)	
		Abnormal (+)	Normal (-)
AI output	Abnormal (+)	35,461	9,503
	Normal (-)	4,539	30,497
	Total	40,000	40,000

Accuracy

Sensitivity (Abnormal)

Specificity (Normal)

ITMS - International TeleMedical System, BR - Brazil, CO - Colombia, EKG - Electrocardiogram, AI - Artificial Intelligence, MOB - Mobile digital transmission, TTP - Trans TelePhonic transmission, Abn - Abnormal, Nor - Normal