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Machine Learning-based 30-day Hospital Readmission Prediction Model for COPD Patients to Combat COVID-19 Pandemic Crisis

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***Abstract*— Chronic Obstructive Pulmonary Disease (COPD) patients have the serious health concern in COVID-19 pandemic, since their treatment and disease management severely affected available medical resources, specifically related with pneumonia and lung disease. Our Machine Learning (ML) based prediction model looks into the human body motion data from physical activity (PA) in daily living recorded with an accelerometer-based wrist-worn device, and predicts 30-day hospital readmission (RA) for COPD patients. For 21 actual RA events, our model predicted 71 RA events with positive prediction rate 76.19%, missed prediction rate 23.81% and sensitivity 83.87%.**

I. Motivation

With COVID-19 pandemic spreading worldwide, it has overburdened medical resources and disrupted medical services. An estimated 300 million cases of COPD worldwide who are more vulnerable to catch the infection and develop the more severe form of the COVID-19 [1]. Hospital readmission after discharge, COPD ranks 4th, but pneumonia patients also exhibit COPD symptoms, therefore, in total COPD ranks 2nd in hospital readmission. We aim to predict readmission in next 30 days by looking into the different PA in daily living with an accelerometer-based wrist-worn device [2], and analyzing PA data using ML models. This could reduce too frequent hospital readmissions, and COPD patients can prepare for their hospital readmission in advance without any hassle.

II. Method

PA data recorded from 16 COPD patients for total of 3,565 days using GENEActiv device configured at a sampling frequency of 20.0 Hz, ±8g at a 12-bit digital resolution and any readmission information from clinical status. We have predicted readmission and reported in [3], and introduced Activity Index (AI) as fundamental quantified unit of PA as:

$$A_j = \sqrt{(a_{x\_j}^2 + a_{y\_j}^2 + a_{z\_j}^2)}; \qquad \mu = \frac{1}{N}\sum_{j=1}^{j=N} A_j$$

$$\sigma_k = \sqrt{\frac{1}{N}\sum_{j=1}^{j=N}(A_j - \mu)^2}; \qquad AI = \sum_{k=1}^{k=12} \sigma_k$$

$\boldsymbol{A_j}$: Resultant acceleration at instance $\boldsymbol{j}$; $\boldsymbol{\mu}$: Mean of resultant acceleration for $\boldsymbol{N = 100}$; $\boldsymbol{\sigma_k}$: True acceleration, without gravity $\boldsymbol{AI}$: Fundamental quantified minute-wise unit of PA.

Fig. 1 shows a representation of hierarchical processing of the time-series PA data in which network-weights are initialized randomly. X_1, X_2, …, X_N represent different time-dependent PA signals which forms N-layer of the deep neural network, and initial random weights $w_1, w_2, \ldots, w_n$ updated after iterative training to w_i' for each corresponding value of $i = 1, 2, \ldots, n$ and repeated till propagate error is minimized. Data prepared using AIs and RA status divided into two parts.

In our previous work [3], training-testing data in 7:3 ratio, ML model trained and generated prediction probabilities using testing data. Further improvement is, using 7 days PA data as testing data for a pre-trained, k-fold cross validated ML model trained with different supervised learning mode to generate the risk of hospital RA as probability values in between 0~1.

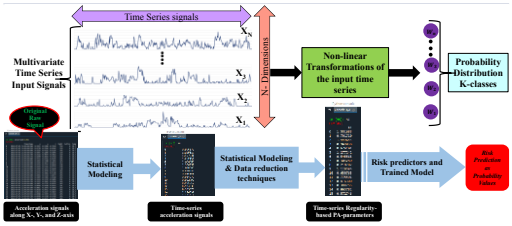

Fig. 1. Hierarchical processing of the time-series PA data using ML model

III. Results & Discussion

Analyzing PA data using ML model, we predicted 71 RA events for 21 actual hospital readmissions in which 26 were true and 55 false predictions. After using present method, positive prediction rate improved from 52.38% to 76.19% and missed prediction rate reduced from 47.52% to 23.81%. Table I lists a comparison of statistical performance parameters between without ML model and with ML model.

TABLE I. Summary of Model Performance

Hospital RA Prediction	Sensitivity	Precision	True Positive	False Positive	False Negative
Without ML	0.6296	0.3778	0.6296	0.6222	0.3703
With ML	0.8387	0.3210	0.8387	0.6790	0.1613

These results hint that RA can be predicted using PA data in daily living and ML model. Since, health condition of COPD patient is a quite complex parameter, PA data could be a major indicator of it, but it cannot be exhaustive. Therefore, we observe a high rate of false positive, this can also be related with ML model's prediction error-limitations. Considering COVID-19 pandemic, this approach to predict RA in next 30 days will really help COPD patients for their rehospitalization and reduce stress on overly burdened medical resources.

References

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