Case Study #4 – The Thyroid System

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Xia, Hui

903459648

Georgia Institute of Technology

1. **How can technology be used to inform patients regarding the interpretation of their thyroid testing results?**

    A. **Computational technology can help to inform the patients regarding the interpretation of their thyroid testing results through telemedicine**. Telemedicine solutions allow patients to interact with healthcare providers remotely with internet service, such as smartphone. Although recent studies reveal that concordance between telemedicine and the actual in-person physical examination is still poor (Akhtar et al., 2018), telemedicine can provide convenience for healthcare providers to inform the patients about the interpretation on their testing results in electronic form (Ellis, Mayrose, Jehle, Moscati, & Pierluisi, 2001).

    B. **Computational technology such as machine learning and big data can help the patient to intercept their thyroid testing results.** For standardized and well-practiced testing such as thyroid testing, it is rather feasible to help the patient to intercept their thyroid testing results themselves with the guidance built by professional healthcare provider (Anbarzadeh & Davari, 2015). Various studies have implemented machine learning algorithms to help patient decision-making. A good example is, Anbarzadeh et al. have implemented a fuzzy algorithm to help the patients to self-analyze testing reports related to five kinds of diseases, and provide suggestions for the patient (Anbarzadeh & Davari, 2015).

2. **How can technology be used to help doctors navigate the highly personalized future of test interpretation?**

    A. **Computational technology can build thyroid model, which help the doctors obtain better understanding of the thyroid testing data**. As future test interpretation will be highly personalized, a detailed understanding on how the thyroid functions and affects the other systems of the human body. For example, which hormone at upstream, at what concentration threshold, will stimulate the generation of Thyroid-Stimulating Hormone (TSH), and what hormone downstream, at what concentration, will be generated due to the effect of TSH. These are values that need to be investigated quantitatively.

    Various models have been built to gain an understanding of the thyroid. Degon et. al. have built a computational model to understand intrathyroidal iodide metabolism, which is the process that generates TSH (Degon, Chipkin, Hollot, Zoeller, & Chait, 2008). Willemin and Lumen proposed another model to quantitatively simulate the mechanism of thiocyanate kinetics actions in thyroid using a Bayesian framework (Willemin & Lumen, 2016). Recently, thanks to the fast development of computational power, such modeling has progressed to molecular level. Tomei et. al. implemented a neural network Bayesian classifier to model the correlation between q-PCR results (on expression level of 9 genes: KIT, SYNGR2, C21orf4, Hs.296031, DDI2,

CDH1, LSM7, TC1, and NATH, which represent known biomarkers) and thyroid nodules (Tomei et al., 2012).

B. **Computational technology can help doctors to interpret thyroid diagnosis results.** Beyond building up understanding of thyroid and the hormone, a more practical application of computational technology is to directly help doctors to perform diagnosis based on thyroid testing results. The Tomei paper that we have discussed above is a good example. By feeding their algorithm data from malignant and benign thyroid testing results, the genetic classification obtained with their model could accurately differentiate malignant from benign thyroid lesions (Tomei et al., 2012). As Thyroid nodules is a very common problem, and the majority (>95%) of them are benign, widely accepting and practicing this machine learning algorithm could potentially save heath care resource and bring down testing cost significantly.

C. **Computational technology could help in screening for personalized drug.** The ultimate target for thyroid testing interpretation is to suggest proper treatment method, if the thyroid testing indicate positive result for any results. Recently, gene therapy drugs have been used in cancer treatment. The gene therapy drugs are usually inhibitors that could block certain gene pathways that are considered related to the cancer. However, due to personal difference on cancer drug resistance, the drug composition that could reach optimized treatment result is always different on each patient individually.

To face this challenge, various models are developed to facilitate drug screening (Xia et al., 2019) (Yes, I am citing my own paper here). Computational technology have been used to drug-screen gene therapy drugs for thyroid-related cancer. For example, Giani et. al. developed a computational framework to suggest new potential targets to overcome drug resistance for vemurafenib, a selective BRAF inhibitor (BRAF mutation is a gene mutation detected in thyroid cancer) (Gianì et al., 2019).

3. **How could ML be used to help correlate patient symptoms with test results?**

A. **To correlate patient symptoms with test results, a ML classifier with high interpretability should be build.** The reason why machine learning is suitable for testing result interpreting is its high prediction power. However, it is well-known that these is a trade-off between prediction power and interpretability for machine learning models. Black box models such as SVM and deep learning could reach high prediction accuracy, but are in general not helpful in improving our understanding on 'why so?', as the reasons on why any given prediction is made is usually difficult, if not impossible, to understand. Thus, ML algorithms with good interpretability and reasonable prediction power, such as Naïve Bayes, are more suitable for medical diagnosis. This is because that such models can help doctors to know

both the prediction and why the predictions are made, i.e. help correlate patient symptoms with test results (Kim, Cho, & Oh, 2017).

B. **To correlate patient symptoms with test results, big data could be used.** To find the trend on how certain symptom, or combination of symptoms, could be related with test results, the data size need to be large enough to be partitioned into proper training, validation, and test set. Azar et. al. implemented a fuzzy-classifier algorithm based on big data, which suggest correlations between the thyroid testing result with correlated potential and hidden diseases (Azar & Hassanien, 2015).

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