Anti-VEGF response prediction towards change in OCT central subfield thickness (CST) for diabetic macular edema (DME) patients

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PURPOSE

- Among the treatment options available for DME, intravitreal injections of anti-VEGF have been the most practiced option.
- However, immediate post-injection response to the anti-VEGF injection varies from patient to patient.
- In order to assist clinicians in optimizing treatment, we developed an automatic algorithm that predicts the potential change in CST for a given DME patient before administrating the anti-VEGF injection.

METHODS

- For the development and verification of the **machine learning (ML) models**, we collected data from a total of 906 DME patients who received anti-VEGF treatment. Figure 1 shows the patients' distribution.
- Each patient's multiple visit data points were collected where both pre- and post-injection OCT scans were acquired using CIRRUS™ HD-OCT 4000/5000 (ZEISS, Dublin, CA) with signal strength ≥ 4.
- The patients' data were divided into **train and test sets containing 775 and 131 patients' data,** respectively.
- **25%** of cases **the CST value increased** after anti-VEGF treatment. Figure 2 shows the percentage reductions.

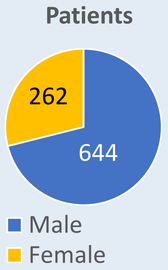

Figure 1. DME patients' distribution

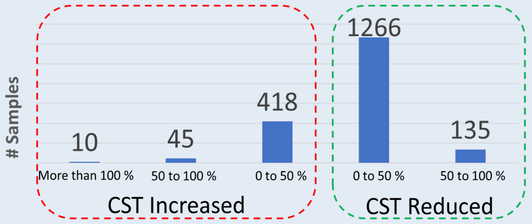

Figure 2. Percentage reduction for 1874 samples from 906 DME patients

Machine learning models predict response of Anti-VEGF injection for DME patients

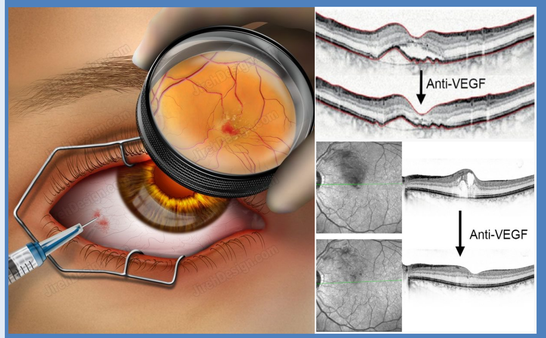

Figure 3. Effect of anti-VEGF injection observed in OCT images

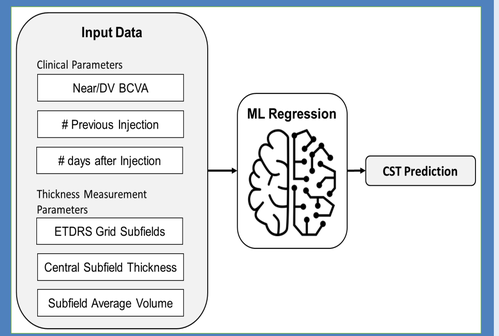

Figure 4. Schematic diagram of ML based CST prediction

# Injection Administered	≥ 1 Injection	≥ 2 Injection	≥ 3 Injection	> 3 Injection
Linear Regression	0.64	0.71	0.72	0.82
SVR RBF Kernel	0.50	0.53	0.53	0.68
SVR Linear Kernel	0.65	0.73	0.75	0.85
Random Forest	0.63	0.66	0.68	0.79

Figure 5. Correlation coefficient for ML regression models for various scenarios

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AV (C), RR (C), CD (C), MG (E), GB (E) - Carl Zeiss India (Bangalore) Pvt. Ltd.

- Four benchmark models including Linear Regression, Support Vector Regression (SVR) with Radial Basis Function (RBF) kernel, SVR with linear kernel and Random Forest (RF) were trained using clinical parameters such as patient's age, gender, near BCVA value, distance vision (DV) BCVA value, pre-injection CST value, the other eight ETDRS grid values, number of previous anti-VEGF injections, and number of days after injection.
- Figure 3 shows how the effect of anti-VEGF injection is observed in OCT images. Figure 4 shows the schematic diagram of the ML model development.
- Using the test set, the performance of the CST change prediction algorithms was evaluated in terms of correlation coefficient (CC). The performance of all 4 models was further evaluated for four different scenarios - number of injections administered: ≥ 1, ≥ 2, ≥ 3 and > 3.

RESULTS

- SVR with linear kernel model achieved best performance in terms of CC with 0.65, 0.73, 0.75 and 0.85 for four scenarios, respectively.
- Figure 5 shows the performance of all four ML models for the four scenarios.
- Linear regression, RF and SVR with RBF kernel model perform in the descending order of correlation coefficient following SVR with linear kernel model.

CONCLUSIONS

- We demonstrated how various ML regression models perform for predicting the change in CST for the patients undergoing anti-VEGF treatment.
- Linear SVR achieved best correlation coefficient of 0.85 for more than 3 injections scenario.
- Machine learning-based models may help specialists to better plan individualized treatment of DME patients.