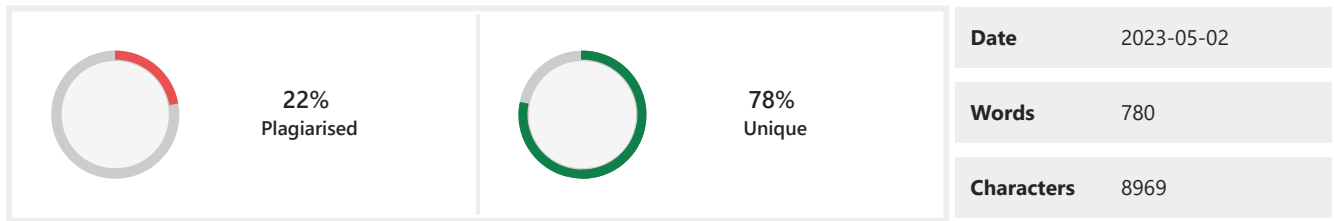


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CHAPTER 6: CONCLUSION AND FUTURE RECOMMENDATIONS

1.

1.1. Conclusion

The product of this work, Electric Vehicle Charging Station Recommendation System, is a web-based application that provides a platform that recommends EV charging stations to the user in their desired location. The memory-based approach of cosine similarity and weighted average allows the system to have decent scalability on co-related items. The system has functional authentication, similarity calculation during insertion, rating, and recommendation. The system is able to recommend the charging station in the said location and the algorithm functions as intended. Existing recommendation systems had a problem of specialisation. They were either too technical and thus overlooked the human aspect as EV charging is not a quick endeavour, or overlooked the technical aspect and were recommending based on ratings of users alone, which in times recommended incompatible charging stations. The system incorporates both the technical and human aspects of the charging station to provide a better recommendation for the users.

1.2. Future Recommendations

In spite of the system having good performance, the system could still be improved upon. The system can incorporate maps and use dynamic distance computation to provide a more dynamic system to the users as well as the admin. PHP is not well suited for implementation of high-end ML and AI algorithms. A change in the choice of the backend framework could allow implementation of a hybrid filtering approach, despite being highly complex. Finally, in the era of real-time technology, the system could be subject to further improvements by adding real-time booking and scheduling of the EV charging station ports.

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APPENDIX

Snippets of major source code components

Computation of similarity scores

```
function calculateSimilarityScores($cs1, $cs2) {
    $chargingStationModel = new ChargingStation();
    $cs_att_1 = $chargingStationModel->getChargingStationAttributes($cs1);
    $cs_att_2 = $chargingStationModel->getChargingStationAttributes($cs2);
    $ab = $cs_att_1[0]->ac_ports_fast * $cs_att_2[0]->ac_ports_fast +
    $cs_att_1[0]->dc_ports_fast * $cs_att_2[0]->dc_ports_fast +
    $cs_att_1[0]->ac_ports_regular * $cs_att_2[0]->ac_ports_regular +
    $cs_att_1[0]->dc_ports_regular * $cs_att_2[0]->dc_ports_regular +
    $this->distance_scale($cs_att_1[0]->nearest_restaurant) *
    $this->distance_scale($cs_att_2[0]->nearest_restaurant) +
    $this->distance_scale($cs_att_1[0]->nearest_shopping_mall) *
    $this->distance_scale($cs_att_2[0]->nearest_shopping_mall) +
    $this->distance_scale($cs_att_1[0]->nearest_cinema_hall) *
    $this->distance_scale($cs_att_2[0]->nearest_cinema_hall);
    $aSquared = $cs_att_1[0]->ac_ports_fast * $cs_att_1[0]->ac_ports_fast +
    $cs_att_1[0]->dc_ports_fast * $cs_att_1[0]->dc_ports_fast +
    $cs_att_1[0]->ac_ports_regular * $cs_att_1[0]->ac_ports_regular +
    $cs_att_1[0]->dc_ports_regular * $cs_att_1[0]->dc_ports_regular +
    $this->distance_scale($cs_att_1[0]->nearest_restaurant) *
    $this->distance_scale($cs_att_1[0]->nearest_restaurant) +
    $this->distance_scale($cs_att_1[0]->nearest_shopping_mall) *
    $this->distance_scale($cs_att_1[0]->nearest_shopping_mall) +
    $this->distance_scale($cs_att_1[0]->nearest_cinema_hall) *
    $this->distance_scale($cs_att_1[0]->nearest_cinema_hall);
    $bSquared = $cs_att_2[0]->ac_ports_fast * $cs_att_2[0]->ac_ports_fast +
    $cs_att_2[0]->dc_ports_fast * $cs_att_2[0]->dc_ports_fast +
    $cs_att_2[0]->ac_ports_regular * $cs_att_2[0]->ac_ports_regular +
    $cs_att_2[0]->dc_ports_regular * $cs_att_2[0]->dc_ports_regular +
    $this->distance_scale($cs_att_2[0]->nearest_restaurant) *
    $this->distance_scale($cs_att_2[0]->nearest_restaurant) +
    $this->distance_scale($cs_att_2[0]->nearest_shopping_mall) *
    $this->distance_scale($cs_att_2[0]->nearest_shopping_mall) +
    $this->distance_scale($cs_att_2[0]->nearest_cinema_hall) *
    $this->distance_scale($cs_att_2[0]->nearest_cinema_hall);
    if ($aSquared == 0 || $bSquared == 0) {
        $similarityScore = 0;
    } else {
        $similarityScore = $ab / (sqrt($aSquared) * sqrt($bSquared));
    }
    return $similarityScore;
}
```

Computation of missing rating and recommendation

```

function getRecommendation(Request $request) {
    $ratingsModel = new Ratings();
    $chargingStationModel = new ChargingStation();
    $recommendationRating = [0, 0, 0];
    $recommendations = [0, 0, 0];
    $user_rating = $ratingsModel->userRatings();
    $chargingStationLocation = '';
    if($user_rating->count() session()->flash('error', 'Please rate at least 3 charging stations.');
```

```

    return redirect()->route('recommendations.index');
} else {
    if($request->get('ward_enabled') == 0) {
        $chargingStationLocation =
        $chargingStationModel->getChargingStationNoWard($request);
    } elseif ($request->get('ward_enabled') == 1) {
        $chargingStationLocation =
        $chargingStationModel->getChargingStationWard($request);
    }
    foreach ($chargingStationLocation as $csl) {
        $ratingEstimateNum = 0;
        $ratingEstimateDen = 0;
        foreach ($user_rating as $ur) {
            $similarityScore = $this->calculateSimilarityScores(
            $ur->charging_station, $csl->charging_station);
            $ratingEstimateNum = $ratingEstimateNum + $ur->rating * $similarityScore;
            $ratingEstimateDen += $similarityScore;
        }
        if ($ratingEstimateDen == 0) {
            $ratingEstimate = 0;
        } else {
            $ratingEstimate = $ratingEstimateNum / $ratingEstimateDen;
        }
        if ($ratingEstimate >= $recommendationRating[0]) {
            $recommendationRating[2] = $recommendationRating[1];
            $recommendationRating[1] = $recommendationRating[0];
            $recommendationRating[0] = $ratingEstimate;
            $recommendations[2] = $recommendations[1];
            $recommendations[1] = $recommendations[0];
            $recommendations[0] = $csl->charging_station;
        } elseif ($ratingEstimate >= $recommendationRating[1]) {
            $recommendationRating[2] = $recommendationRating[1];
            $recommendationRating[1] = $ratingEstimate;
            $recommendations[2] = $recommendations[1];
            $recommendations[1] = $csl->charging_station;
        } elseif ($ratingEstimate >= $recommendationRating[2]) {
            $recommendationRating[2] = $ratingEstimate;
            $recommendations[2] = $csl->charging_station;
        }
    }
}

$provinceModel = new Provinces();
$data['provinces'] = $provinceModel->selectProvinces();
$data['user'] = Auth::id();
$recommendation1 =
$chargingStationModel->getFinalRecommendation($recommendations[0]);

```

```

$recommendation2 =
$chargingStationModel->getFinalRecommendation($recommendations[1]);
$recommendation3 =
$chargingStationModel->getFinalRecommendation($recommendations[2]);
$data['recommendations'] =
collect([$recommendation1, $recommendation2, $recommendation3]);
$data['actual_cs'] = $recommendations;
$data['estimated_rating'] = $recommendationRating;
return view('recommend.recommend', compact('data'));
}

```

```

Discretisation of Distances
function distance_scale($distance_str) {
$distance = (float)$distance_str;
if ($distance == 0) {return 0;}
else if ($distance

```

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