SBS Transit Hackathon 2024

PS1: Develop a brightness measurement system for EDS on buses and establish readability limits

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Current LED Lighting System Issues On SBS Buses

The predominantly orange LED lighting on SBS buses

- **Harder for passengers to read signage**, schedules and other information on the panel
- **Distort color perception**, especially difficult for color-blind people to read
- Creates a **subdued and sleepy ambience**, not ideal for transit environment

Lack of brightness levels in current LED lighting system

- Currently only **a few levels** of LED brightness
- **Not enough options** to accurately adjust brightness levels optimally
- Sometimes **brightness is too high/low** for passengers, resulting in discomfort

How to solve these issues?

Possible Solution

Install LED lighting systems that:

- ✓ **Are white** (no other color to prevent distraction)
- ✓ A **continuous range** of brightness levels (eg: 500 to 1000 nits)
- ✓ **Change brightness levels automatically** based on certain factors (Discussed in next slide)

Factors Affecting EDS Display Visibility

Passenger Demographics

Older individuals often experience reduced visual acuity compared to younger people

Light Conditions In Bus

Variations in the internal lighting levels across different buses can impact visibility of EDS panels from inside the bus

Weather Conditions

Days with severe thunderstorms or intense sunlight can significantly reduce the visibility of the EDS panel from outside

Distance From Passenger To Panel

As the distance between passengers and the EDS panel increases, visibility tends to decrease

Bus Models

Certain bus models such as MAN A95 have more tinted EDS panels compared to MAN A22 and Mercedes-Benz Citaro, lowering visibility

Cleanliness Of EDS Panel

Recently cleaned EDS panels offer improved visibility compared to those that have not been cleaned for an extended period

How To Determine Optimal Brightness Levels?

Step 1:
Data Collection And Preparation

Collect Passenger Data
Obtain Passenger Feedback
Data Cleaning And Manipulation

Step 2: Establish Readability Limits

Gauge Best Brightness Levels For Various Scenarios

Step 3:
Machine Learning Model Implementation

Implementing Decision Tree Model
Obtaining Majority Predicted Feedback

Step 4:
Testing And Gauging Accuracy Of Model

Undergo User Testing
Perform Simulations
Check Satisfaction >= 95%

Step 5: Re-Implementing Machine Learning Model (If Needed)

Check New Satisfaction Rates
Evaluate Ways To Increase LED Lifespan
Evaluate Feasibility Of Solution

Data Process Lifecycle

Step 1: Data Collection And Preparation

Collect Data Regarding:

- ✓ **Seniority Of Passenger** (eg: Student, Middle-Aged, Senior Citizen)
- ✓ **Bus Model Passenger Is Travelling On** (eg: MAN A22, Volvo B9TL)
- ✓ **Weather Condition Outside** (eg: Sunny, Cloudy, Thunderstorms)
- ✓ **Time Of Day** (eg: Early Morning, Late Afternoon, Night)
- ✓ **Date Of Previous Cleaning Of EDS Panels** (eg: 1 November 2024)
- ✓ **Approximate Passenger Distance From EDS Panel** (eg: 5 Metres)
- ✓ **Current Brightness Of EDS Panels** (eg: 200 nits)

Obtain Passengers' Feedback On The Brightness Of The EDS Display
(Way Too Bright/Slightly Too Bright/Just Right/Slightly Too Dim/Way Too Dim)

Obtain **at least 10000 passengers** for better accuracy of Machine Learning model implemented in subsequent steps

Preferably:

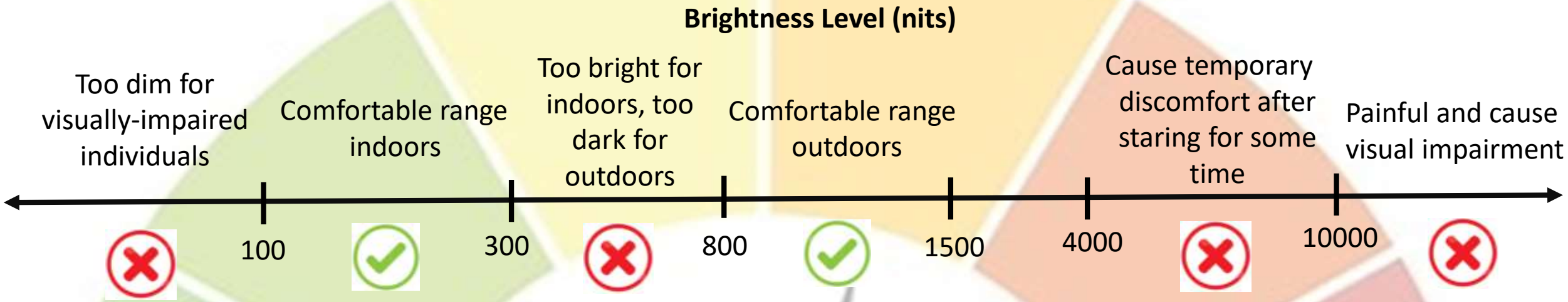
- **Mix Of Ages**
- **All Bus Model Types**
- **Various Weather Conditions**
- **Various Times Of Day**

This will **reduce the biasnesses** of the Machine Learning model as dataset is more balanced

We will take into account both the EDS panels outside and inside the buses

Step 2: Establish Readability Limits

We can **use a brightness scale** to determine the optimal brightness level for both indoor and outdoor EDS panels.
The appropriate brightness levels will be taken into consideration when implementing the Machine Learning model.



The suitable brightness level ranges are:

Outdoor EDS Panel: **800 nits to 1500 nits**
Indoor EDS Panel: **100 nits to 300 nits**

We can then gauge the more exact brightness level to be used based on factors from Slide 2 (eg: Weather Conditions, Bus Model, Panel Cleanliness etc.)

Examples:

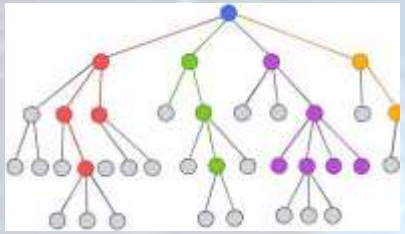
Scenario 1 - Severe thunderstorm, bus with tinted panels, not cleaned for a long time
Outdoor Panel: **800 nits** , Indoor Panel: **300 nits**

Scenario 2 - Sunny, bus without tinted panels, cleaned yesterday
Outdoor Panel: **1500 nits**, Indoor Panel: **100 nits**

Step 3: Machine Learning Model Implementation

Given: **Categorical data** from dataset obtained in Step 1, coupled with **labels** of passenger feedback on brightness levels, a **Supervised Machine Learning Algorithm** is suitable. We can consider using **Tree-Based Models (Decision Tree)**

Decision Tree Algorithm:



Keep in mind the suitable brightness range levels from Step 2

Feed the cleaned dataset into the Decision Tree model

Example: 50000 rows of passenger data

Use 80% of data to be training set and remaining 20% to be testing set

40000 rows (training)
10000 rows (testing)

Apply Decision Tree Classifier Algorithm on Training data

Implement algorithm for the first 40000 rows

Using Testing data, obtain predicted feedback type for various scenarios

Obtain predicted feedback for the remaining 10000 rows

Increase brightness level

Majority feedback states "too dim"

Apply this brightness level

Majority feedback states "just right"

Decrease brightness level

Majority feedback states "too bright"

The Decision Tree model **can be re-implemented** until an optimal brightness value is obtained for the various scenarios when the **majority predicted feedback type is "just right"**

Step 4: Testing And Gauging Accuracy Of Model

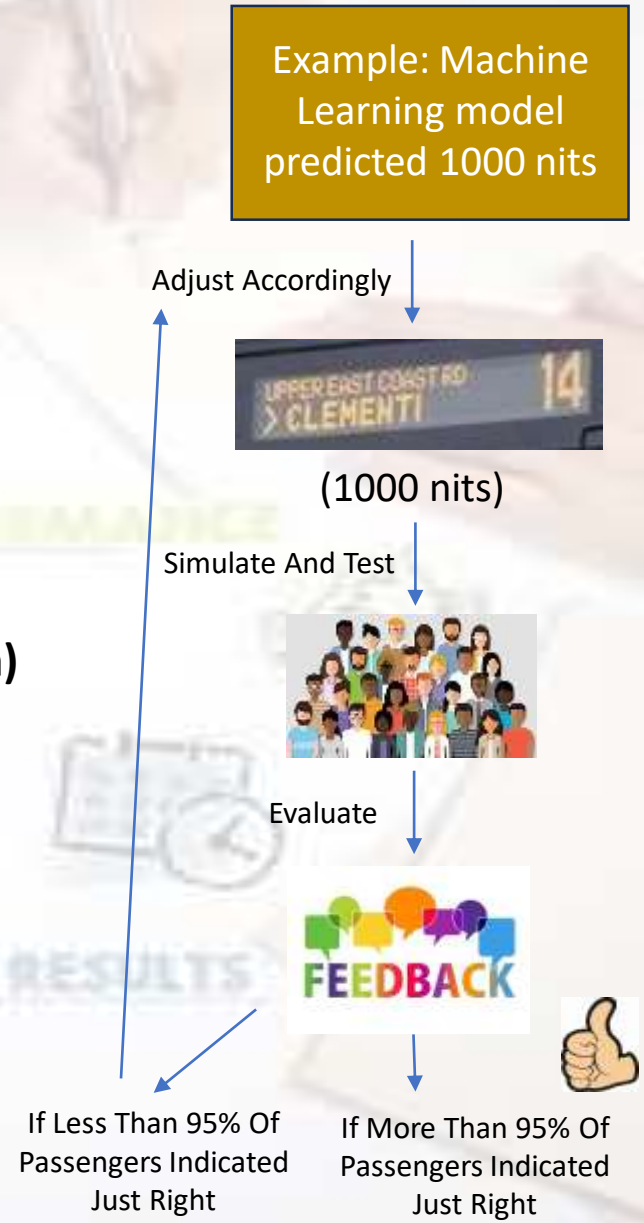
After obtaining the optimal brightness level of the outside and inside EDS panels for the various bus models, we need to perform testing

Testing Process:

1. **Gather a large enough sample of people from various demographics**
2. **Set up different environments to mimic weather conditions (bright sunlight, haze etc.)**
3. **Adjust brightness levels of EDS panels using results from Machine Learning model**
4. **People evaluate the readability of the EDS panels from different distances and angles**
5. **Obtain users' feedback on the brightness of the EDS panels (too bright/just right/too dim)**
6. **Repeat steps 1 to 5, using the various bus models tested**

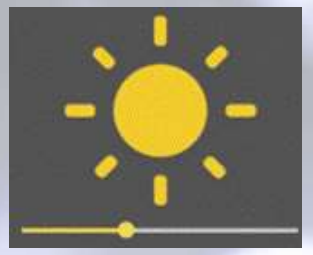
Evaluation Of Accuracy Process:

1. **Calculate the percentage of users who indicated that brightness level is just right**
2. **If percentage is above the 95% requirement, brightness level is optimal**
3. **If percentage is below the 95% requirement, re-adjust the brightness level**



How To Prolong Life Of LED Lights?

Control Brightness Level



Set the brightness level to the minimum required to ensure optimal visibility for passengers

Turn Off When Not Needed

Schedule EDS panels to automatically power off when the bus is not in operation or when visibility is not required

Routine Cleaning of EDS Panels

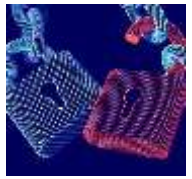
Dust and dirt can accumulate on EDS panels, causing overheating. Regularly clean the panels to ensure optimal heat dissipation

Add Cooling Mechanisms

Consider adding small fans or heat sinks to reduce the temperature inside the EDS enclosure

Reduce Non-Essential Animations

Animations can require more power and wear out LEDs faster. Use static displays to reduce stress on LEDs.



Feasibility Of Solution



Benefits

- ✓ Cost-savings as brightness can be adjusted to a dimmer level when necessary
- ✓ Decision Tree Machine Learning model is efficient to implement with high accuracy
- ✓ Increase lifespan of LED lights when measures to prolong LED lights are implemented
- ✓ Less carbon emissions from LED lights, leading to environmental sustainability.
- ✓ Passengers' moods will be elevated due to more desirable brightness levels , improving customer satisfaction
- ✓ High level of user experience involved due to multiple rounds of testing and obtaining feedback

Limitations/Challenges

- ❖ Privacy issues might surface from passengers when obtaining data about their bus trips
- ❖ Cost required to install cooling mechanisms to the EDS panels for every bus. Changing to multi-level brightness white LED lights might be more expensive than the current LED costs for SBS
- ❖ Readability limits on brightness levels are accurate to the majority of passengers, but there might be certain exceptions (eg: people with disabilities, ultra-sensitive to light)
- ❖ Passengers feedback on brightness suitability might not be honest
- ❖ Some time needed to obtain a large enough number of passengers to survey and experiment