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SIZING THE FUTURE FASHION

RESEARCH PAPER LINK

Team Name : Project IOT

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Team Members Details

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PROBLEM

One of the major problems in the apparel industry is **high return rates** **because standard size charts usually fail to capture individual variations** in body shape, which leads to customer dissatisfaction. According to articles on the internet the size charts are highly inaccurate and **can cover only 20%** of the customers.

SOLUTION

Our AI system develops two types of size charts: **a Standard S, M, L, XL chart** and **a Detailed Body Type chart**. By applying K-Means clustering, we group users into 55 logical body type categories based on body measurements, purchase history, and return data. This enables us to provide precise, **personalized size recommendations** with confidence scores.

IMPACT

Our scaling solution improves size accuracy, **raising** **user adaptability from 20% to 96.4%**. Our personalized recommendations help customers find the right fit for their body type, leading to a **dramatic** **drop in return rates (60% betterment expected)** **and significant growth of revenue**. This powerful innovation will change how we shop completely.

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FIRST STEP

- **Key Segregation :** The size chart varies by **gender(Men/Women)**, **garment type(Top/Bottom)**, and **age(Kid/Adult)**. Each of these categories is addressed separately.
- Users are classified into **55 clusters** based on height, bust size and body shape index(Standard/Rectangle, Apple, Pear, Hourglass, Inverted Triangle)
- **Why 55?** based on the ***research paper***, the customers are divided into 11 major classes based on height and drop value, but this does not take body shape into account. By including 5 body shape, we create 55 clusters.
- This classification covers **96.38%** of the population with specific clusters like "**Rectangle body - small height - medium bust**". Each cluster is defined by detailed user body measurements.
- **Add Size Suggestions :** Introduce a new column of size suggestions (S, M, L, XL) based on the existing size chart (***ISO/TC-133 general size chart***).

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SECOND STEP

- **Develop Confidence Scores** : Create and calculate confidence scores for sizes S, M, L, XL for each class based on specific measurements (e.g., height for “Rectangle - Small Height - Medium Bust”).

- **Generate Size Charts Based on Measurement Priorities** : For men's upper garments, emphasize chest and shoulder measurements. For women's lower garments, focus on hip, waist, and inseam for pants. Adjust confidence scores to enhance fit accuracy. For more details refer ***paper***.

Table 5.6 Primary and Secondary dimensions for garments
(Reproduced from British Standards Institution, 2002)

Garments for Dimensions	Boys		Girls	
	PD	SD	PD	SD
Jackets	Height	Chest girth	Height	Bust girth
Suits	Height	Chest girth	Height	Bust girth
Overcoats	Height	Chest girth	Height	Bust girth
Trousers/Shorts	Height	Waist girth	Height	Waist girth
Skirts	-	-	Height	Waist girth
Dresses	-	-	Height	Bust girth

PD=PRIMARY DIMENSION
SD=SECONDARY DIMENSION

- **Feedback-Driven Refinement** : We gather user feedback on fit experiences, including FitFeedback, return and exchange data, and reasons for returns. Using this feedback, we design an algorithm to update confidence scores and refine the size chart. If a size's **confidence score drops below a threshold (say 0.60)**, we adjust the recommendation to a more accurate size with a higher score, ensuring the chart remains reliable over time.

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SECOND STEP

Cluster	Height (cm)	Weight (kg)	Bust/Chest (cm)	Cup Size	Waist (cm)	Hips (cm)	Shape Index	Suggested Size
Rectangle - Short - Small Bust	155 - 160	50-55	80-85	A-B	60-65	85-90	0	S
Rectangle - Short - Medium Bust	155 - 160	55-60	85-90	B-C	65-70	90-95	0	M
Rectangle - Medium - Small Bust	160-165	55-60	80-85	A-B	60-65	85-90	0	M
Rectangle - Medium - Medium Bust	160-165	60-65	85-90	B-C	65-70	90-95	0	L

** MORE ROWS

DETAILED SIZE CHART

Cluster	Height (cm)
Rectangle - Short - Small Bust	S=0.94 M=0.46 L=0.12 Xl=0.01

CONFIDENCE SCORE TABLE FOR THE RESPECTIVE CELL

The suggested size for each cluster is determined based on confidence scores and the priority of each measurement.

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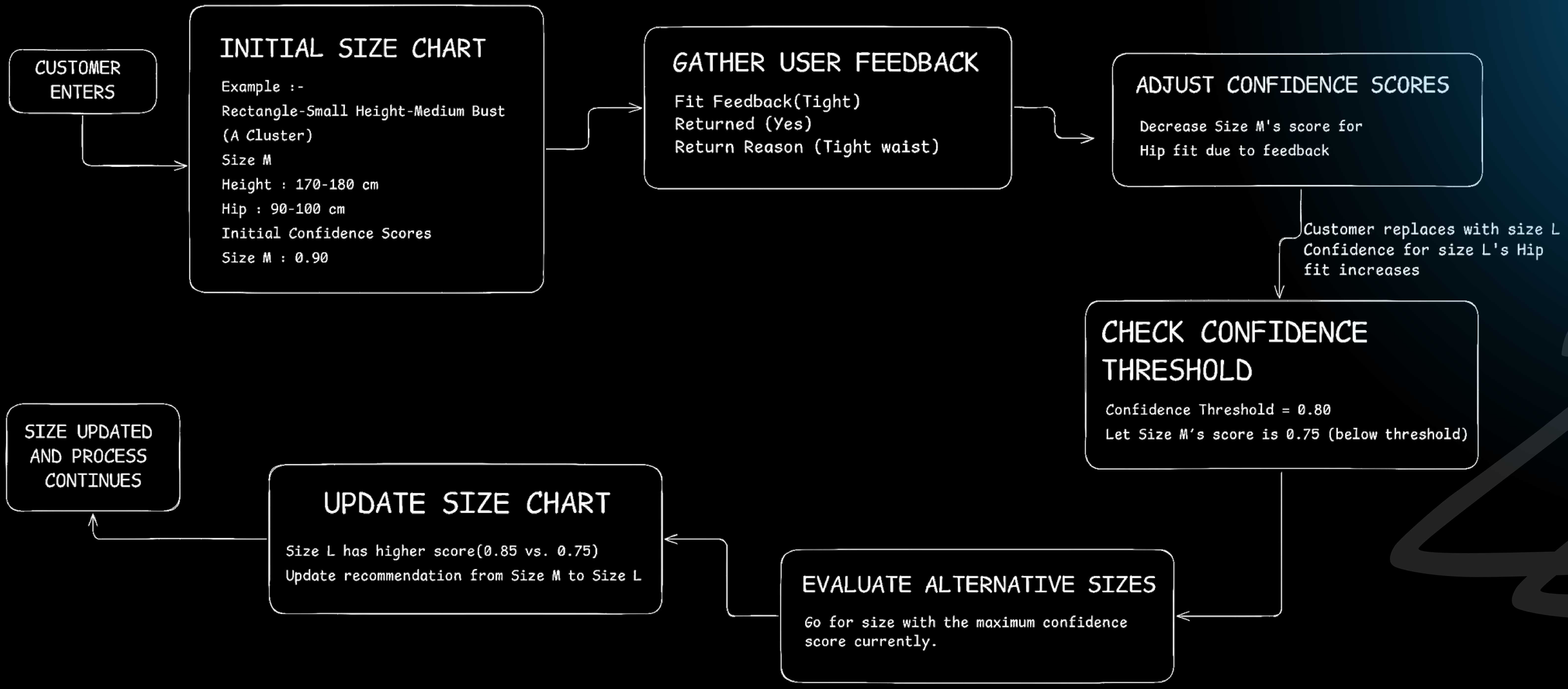
SECOND STEP

Overall flow of the refinement process- Adjusted the initial size chart based on successful purchases and returns, ensuring accuracy by updating size recommendations and finalizing the chart for use.



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SECOND STEP

NULL/AUTO VALUE HANDLING

For the second part we make use of 2 models and data like sales and returns which mainly contains measurements (like height, waist, neck etc). For handling null values we use **Binomial linear expression**.

RESEARCH PAPER LINK : ***https://www.mdpi.com/2227-7390/12/3/497***

Table 7. Binomial linear regression equations composed of height and bust.

Control Part/Body Type	Body Type 1 (Rectangular)	Body Type 2 (Pear)	Body Type 3 (Standard Inverted Trapezoid)	Body Type 4 (Thin Hourglass)
		Height (H)		
Neck Height	0.865H + 0.004B − 3.949	0.812H − 0.04B + 8.125	0.865H − 0.004B − 3.037	0.842H − 0.002B + 0.419
Bust Height	0.776H − 0.086B − 3.637	0.779H − 0.026B − 8.244	0.806H − 0.013B − 13.017	0.807H + 0.077B − 20.826
Waist Height	0.734H − 0.019B − 17.089	0.696H − 0.029B − 10.252	0.734H + 0.026B − 20.158	0.718H + 0.068B − 21.87
Arm Length	0.473H + 0.011B − 23.132	0.389H + 0.049B − 14.128	0.402H − 0.025B − 9.469	0.336H + 0.028B − 3.552
		Bust (B)		
Neck Circumference	−0.04H + 0.212B + 19.551	−0.035H + 0.215B + 18.382	0.037H + 0.238B + 4.71	0.023H + 0.144B + 14.199
Waist Circumference	0.074H + 0.866B − 13.742	−0.034H + 0.938B − 4.835	−0.027H + 0.875B − 2.918	−0.008H + 0.654B + 8.845
Neck Width	0H + 0.077B + 3.981	0.015H + 0.032B + 5.087	0.008H + 0.061B + 3.838	0.007H + 0.025B + 6.932
Shoulder Width	−0.006H + 0.103B + 29.978	0.044H + 0.231B + 11.731	0.063H + 0.211B + 9.88	0.079H + 0.245B + 4.044
Bust Width	0.042H + 0.248B − 0.329	−0.075H + 0.142B + 26.689	−0.019H + 0.25B + 8.937	−0.007H + 0.28B + 3.938

H = HEIGHT, B = BUST

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THIRD STEP

- **Standard Size-Chart** : Currently, size charts follow a standard format with sizes (S, M, L, XL) and their respective measurements. However, our model provides a more detailed size chart. To simplify the selection process and promote **standardization**, we've developed a streamlined version of the size chart. This simplified approach makes it easier for users to choose the right size and **ensures consistency** across different apparel sellers by focusing on broader categories.
- **Reason for 2 Charts** : The generic chart provides an **easy-to-use** overview, while the detailed chart offers precise measurements for a wide range of body types. This combination ensures that users can choose their size accurately while having access to **both simplified and detailed sizing options**.

GENERIC SIZE CHART

Size	Height(cm)	Weight(kg)	Bust/Chest (cm)	Cup Size	Waist(cm)	Hips(cm)
S	150-160	45-55	80-85	A-B	60-65	85-90
M	160-170	55-65	85-95	B-C	65-75	90-100
L	170-180	65-75	95-105	C-D	75-85	100-110
XL	180-190	75-85	105-115	D-E	85-95	110-120

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THIRD STEP - HOW WE MAKE GENERIC SIZE CHART

- **Cluster Assignment** : We use **Gaussian Mixture Models (GMM)** for tackling this task as it handles overlapping clusters and flexible shapes with probabilistic assignments, unlike k-means, which assumes fixed, spherical clusters. We fit a GMM with 4 components (for sizes S, M, L, XL).

$$p(x_i|\mu_k,\Sigma_k) = \frac{1}{(2\pi)^{d/2}|\Sigma_k|^{1/2}} \exp\left(-\frac{1}{2}(x_i-\mu_k)^T\Sigma_k^{-1}(x_i-\mu_k)\right)$$

- **Determining Centroids** : For each gaussian components.

$$\mu_k = \frac{\sum_{i=1}^{N}\gamma_{ik}x_i}{\sum_{i=1}^{N}\gamma_{ik}}$$

$$\Sigma_k = \frac{\sum_{i=1}^{N}\gamma_{ik}(x_i-\mu_k)(x_i-\mu_k)^T}{\sum_{i=1}^{N}\gamma_{ik}}$$

- **Boundary Determination** : Use the GMM to identify where each size group's probability density is high. For example, set boundaries where the density 'p' exceeds a threshold, ensuring measurements within these **ranges are assigned** to the corresponding size group.

$$p(x_i|\mu_k,\Sigma_k) > \text{Threshold}$$

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THIRD STEP - HOW WE MAKE GENERIC SIZE CHART

- **Determine Buffer Size**
  - **Based on Density** : If the density is high, use a smaller buffer to fit the data closely. If density is low, increase the buffer.
  - **Based on Variance** : Use a larger buffer if variance is high to ensure the size range covers more variability. If variance is low, use a smaller buffer.

- **Boundary Adjustment**
  - **Objective** : Create clear, **non-overlapping size ranges**.
  - **Method** : Adjust size boundaries to prevent overlap. For example, if the upper boundary of size j is too close to the lower boundary of size j+1, increase the gap by adjusting the boundaries, where **δ is “buffer”**.

$$\text{Adjusted Min}_j = \max(\text{Min}_j, \text{Max}_{j-1} + \delta_j)$$

$$\text{Adjusted Max}_j = \min(\text{Max}_j, \text{Min}_{j+1} - \delta_j)$$

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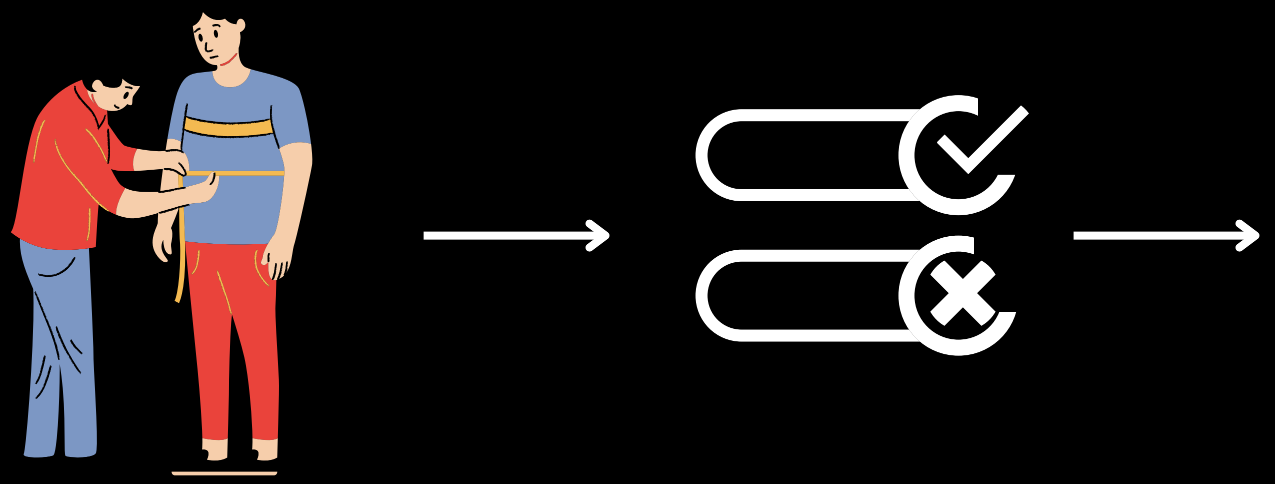
FOURTH STEP

- **User Measurement-Based Size Recommendations** : If users find the charts challenging to interpret, we **recommend sizes based on the measurements** they provide or, if measurements aren't given, use their **previous purchase data** to suggest appropriate sizes. This approach ensures users receive tailored size recommendations, making the selection process easier and more accurate.



Cluster	Height (cm)	Weight (kg)	Bust/Chest (cm)	Cup Size	Waist (cm)	Hips (cm)	Shape Index	Suggested Size
Rectangle - Short - Small Bust	155 - 160	50-55	80-85	A-B	60-65	85-90	0	S
Rectangle - Short - Medium Bust	155 - 160	55-60	85-90	B-C	65-70	90-95	0	M

- **Optimized Sizing Recommender for New Sellers** : When a **new company or product enters** the market and needs more accurate sizes for S, M, L, and XL categories, our system offers a significant advantage. By leveraging our data and advanced models, we create a tailored sizing model that ensures each size accurately fits a representative portion of the population (e.g., 25% for each size). **This approach improves accuracy, inclusivity, customer satisfaction, and reduces return rates**.

IMPLEMENTATION OF IOT

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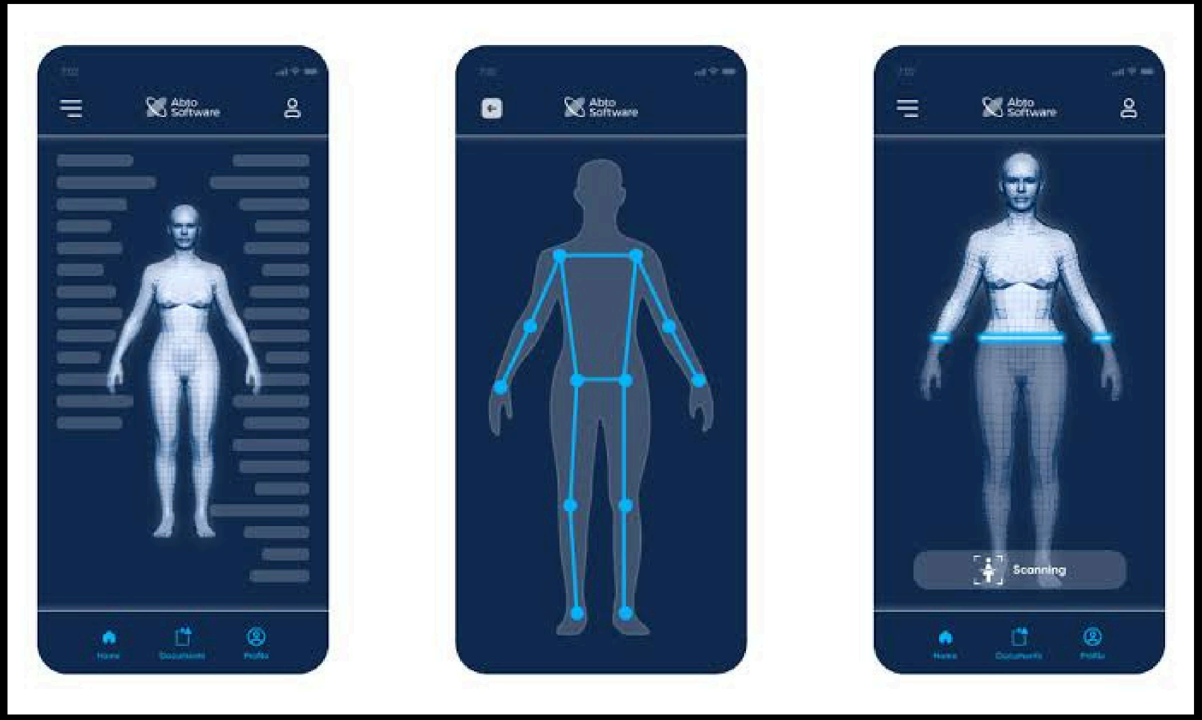
- **Data Capture:** The **VITUS SMART LC3 3D** scanner first captures the user's body dimensions, including height and width, using precise 3D scanning technology.
- **Measurement Analysis:** The captured measurements are processed by the platform's algorithm i.e. **User Measurement-Based Size Recommendations** as mentioned in step 4 to analyze key body proportions and size metrics.



- **Model Categorization:** Based on the processed data, the system categorizes the user into a pre-defined size model that best fits their body structure.
- **Size Recommendation:** The platform then suggests the most suitable size for the user, ensuring personalized and accurate size recommendations for clothing or apparel.

PROTOCOL STACK

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- **Data Link Layer:** The size recommendation request from the customer's browser is sent over **IEEE 802.15.4 protocol** to the local router, ensuring minimum battery consumption of LC3 3D sensors.

- **Transport Layer**: TCP ensures that the user's body measurement data is transmitted **reliably** to the backend without loss or corruption

- **Presentation Layer**: The body measurement data is formatted in JSON, which is then transmitted to the backend. **SSL/TLS** secures this communication, ensuring that the data remains encrypted.

- **Application Layer**: The REST API processes the user's measurements and returns a personalized size recommendation via **HTTPS**, ensuring the user receives secure and accurate results.

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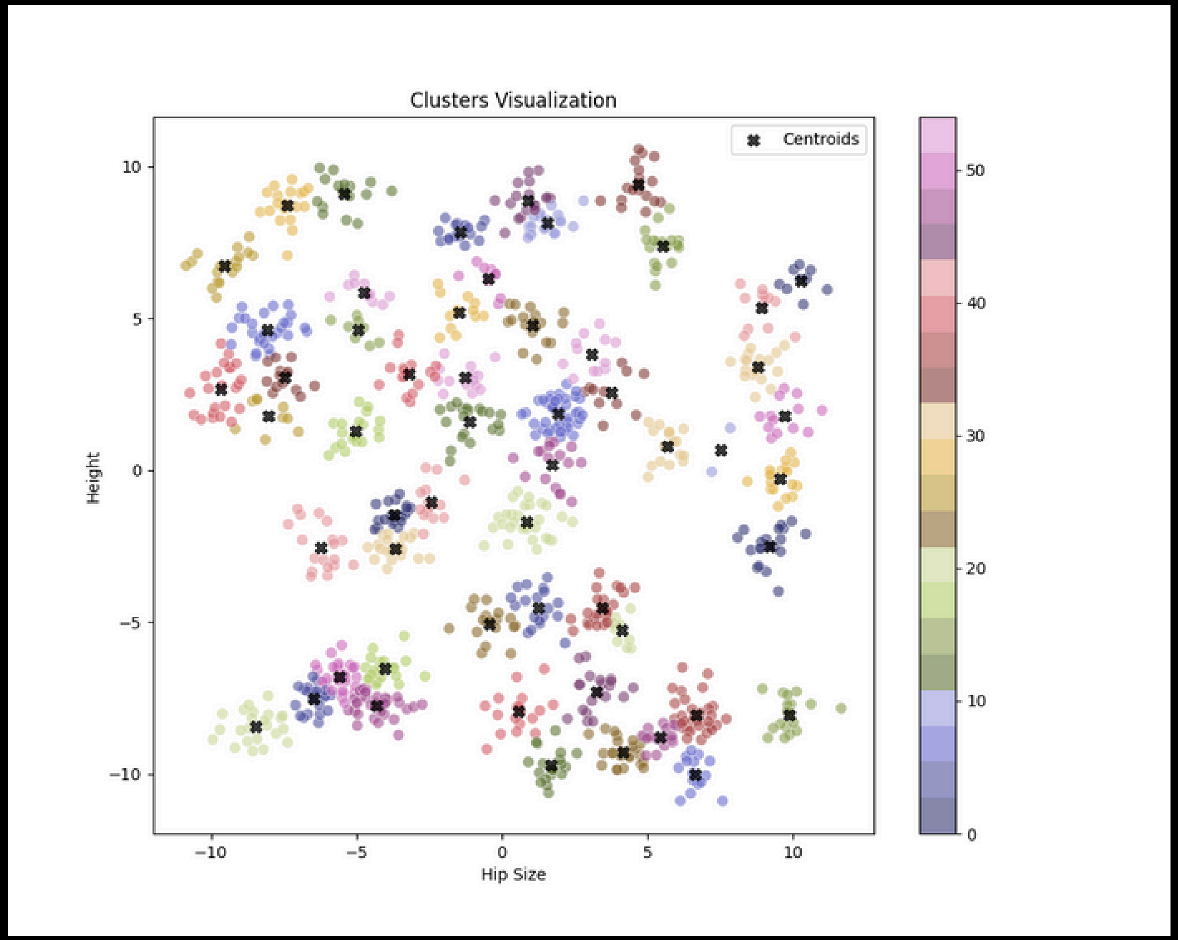
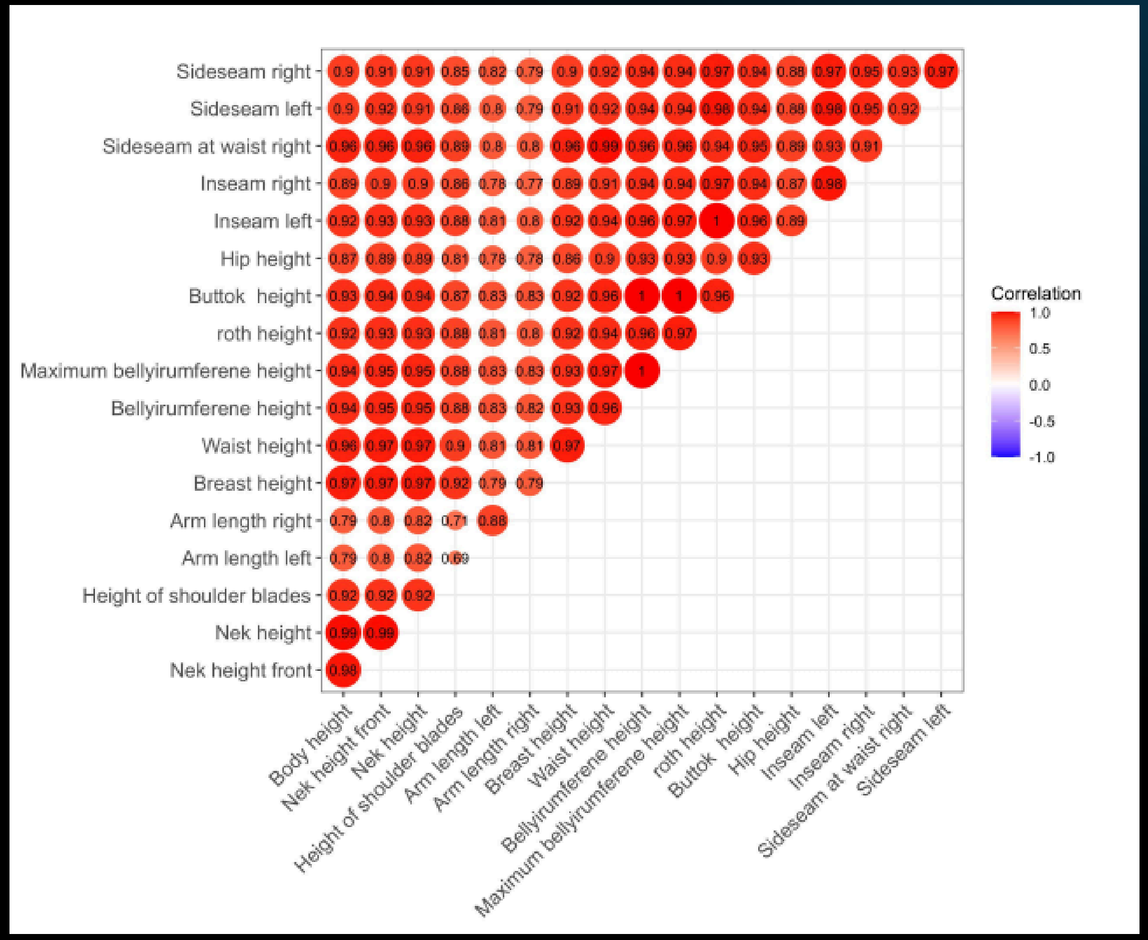
DEPLOYMENT & TECH STACK

- **Scalable Processing** : Use cloud platforms like **AWS or Azure**. Implement **CI/CD** pipelines for seamless model updates.
- **Performance and Management** : Monitor model performance with detailed logging, and maintain versioning for **reliable updates and quick rollbacks**.
- **Tech Stack** : Scikit-learn, Numpy, Pandas, Seaborn, **Docker, Kubernetes**

Analysis charts



55 CLUSTERS EXAMPLE CHART



FACTOR ANALYSIS FOR SIZE CORRELATIONS

FINAL FLOW OF ALL PIPELINES

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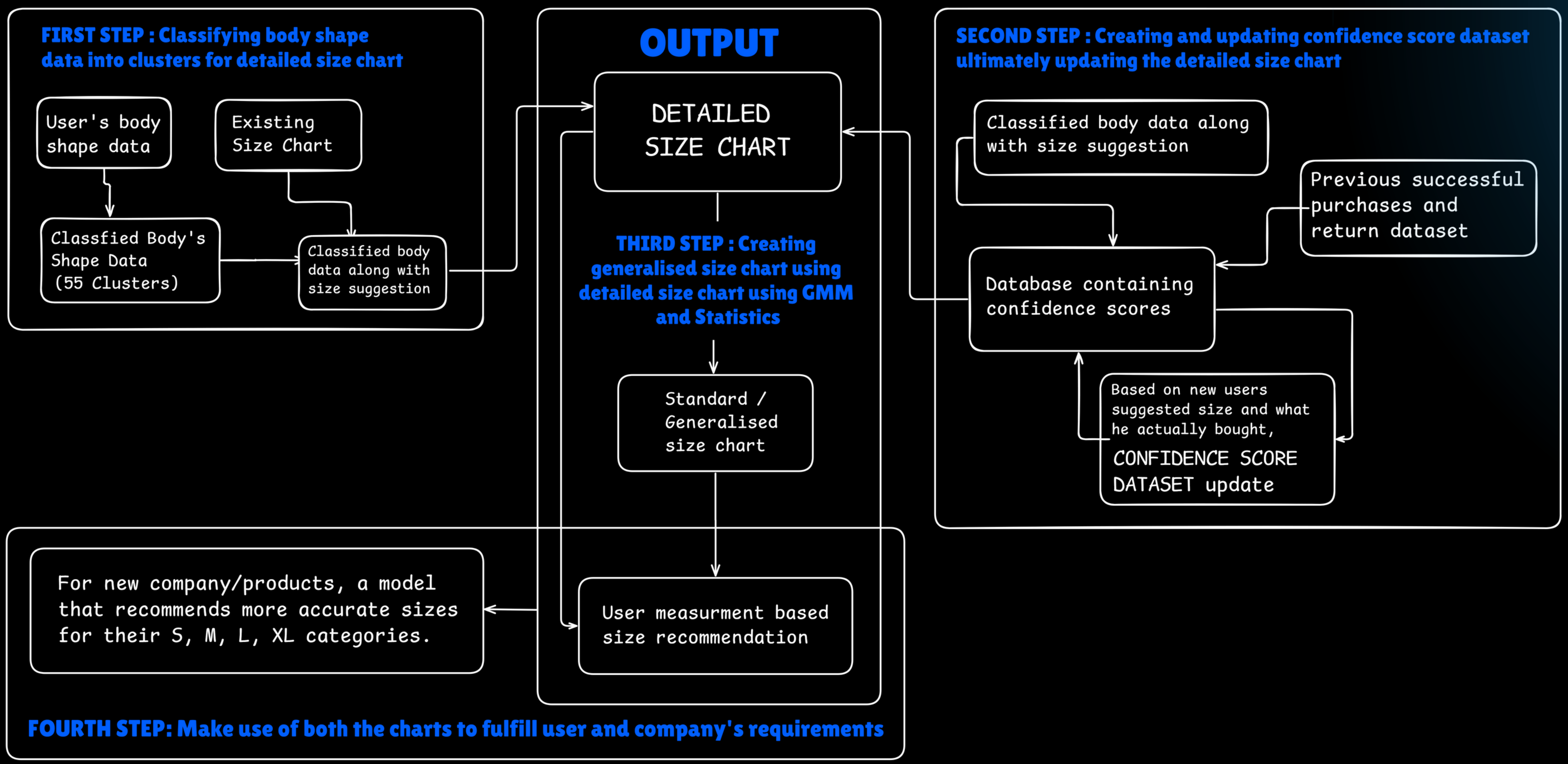

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CHALLENGES

- **Limited availability** of detailed **user measurements and feedback**, which impacts the accuracy and reliability of the size chart.
- We are currently utilizing **55 clusters** as outlined in a research paper. However, several clusters are closely aligned, and it may be more effective to consolidate them. Unfortunately, due to a **lack of available data**, we are unable to do this presently.

LIMITATION

- We have considered the **basic S, M, L, XL but in real this think is not same for all products** like there are **XS and XXL sizes** for few products.
- Our model's **accuracy solely depend** on credibility of **body measurement data.**
- Purchases made for others or **misunderstandings of the size chart** can disrupt the **model's effectiveness,** leading to inaccurate size recommendations.

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RECOMMENDATIONS & FUTURE WORK

- Extend the idea from clothes to other accessories that require size charts like **footwear, eyewear** (goggles), Fashion Accessories, Sports Equipment (like helmets, knee pads, and chest protectors).
- **3D Body Scanning**: Explore integrating **3D body scanning** technologies, which provide **precise measurements**, improving the accuracy of body shape identification and size recommendations.

CITATIONS

- *A statistical model for developing body size charts for garments*
- *Cluster Size Intelligence Prediction System*
- *Comparative analysis of sizing in children's wear between the UK and Korea*

THANK YOU

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