Inter IIT Tech Meet 11.0

COGNITIVE GARAGE

Easy Automation of Complex Decision Making

Step 3 - Presentation

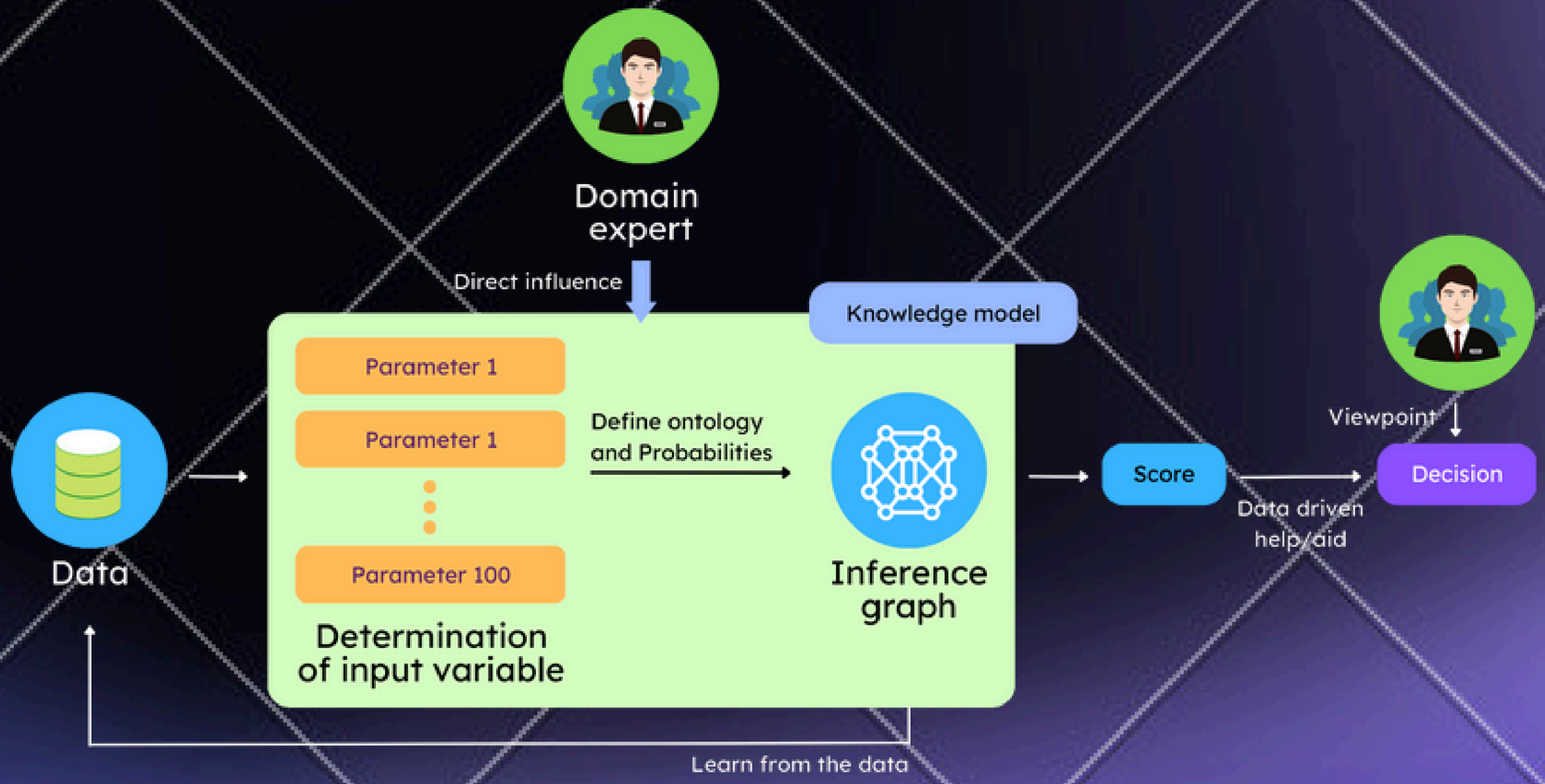
Team 43

Problem Statement

We were asked to work on a use case that requires automation of complex decision-making with inputs from domain experts and other factual data and parameters. The idea had to be such that it could be developed into a potential start-up.

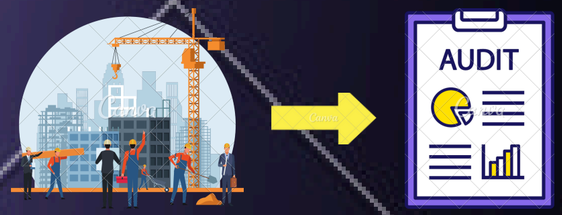
Key Features:

- Benefit of scale
- Improve accuracy
- Shorten the time
- Better decisions



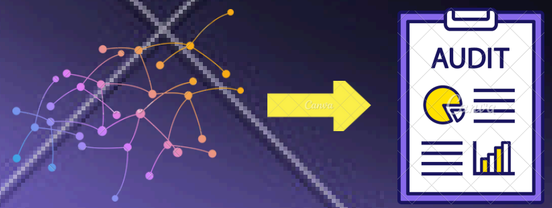
Use Case → Automated Risk Assessment for Infrastructure Auditing

CURRENT PRACTICE



- The Structural auditor collects all relevant data related to the building from past audit reports and building plans
- A visual inspection is performed through which the auditor evaluates the entire building and suggests a few NDTs
- After complete analysis, a structural audit is prepared where the auditor evaluates the damage profile of the building and provides a further action plan

OUR IDEA



- Our model will contain several parameters with integrated inputs from the building's data and the outcomes of the visual inspection
- Based on the correlations, the program will then take these inputs and produce a risk score for the building
- Predicts a probable list of NDTs that should be conducted to pinpoint the problem

Where do we fit in?

16% of India's GDP constitutes of the construction industry

NEED FOR AUTOMATION

The auditing process needs automation to decrease the personal bias of the inspector and malicious practices in suggesting expensive NDTs. We automate this process by building a knowledge model which would help provide a list of NDTs required

WHY BAYESIAN NETWORK?

- Provides a flexible and powerful framework for reasoning about uncertainty making them well-suited for complex decision problems
- Reduces uncertainty by using probabilistic inputs
- Easily interpretable by inspectors and consultants
- Other methods require abundant data and are too complicated to be used by common inspectors

01

NATURAL DISASTERS

India is prone natural disasters which lead to structural failure. According to the NCRB's report 80,000+ people have died due to building collapse from 2000 to 2019

02

INEFFICIENCIES IN WORKFORCE

According to a study the construction and civil auditing industry has seen a 6.27 percent decline due to under skilled workforce

03

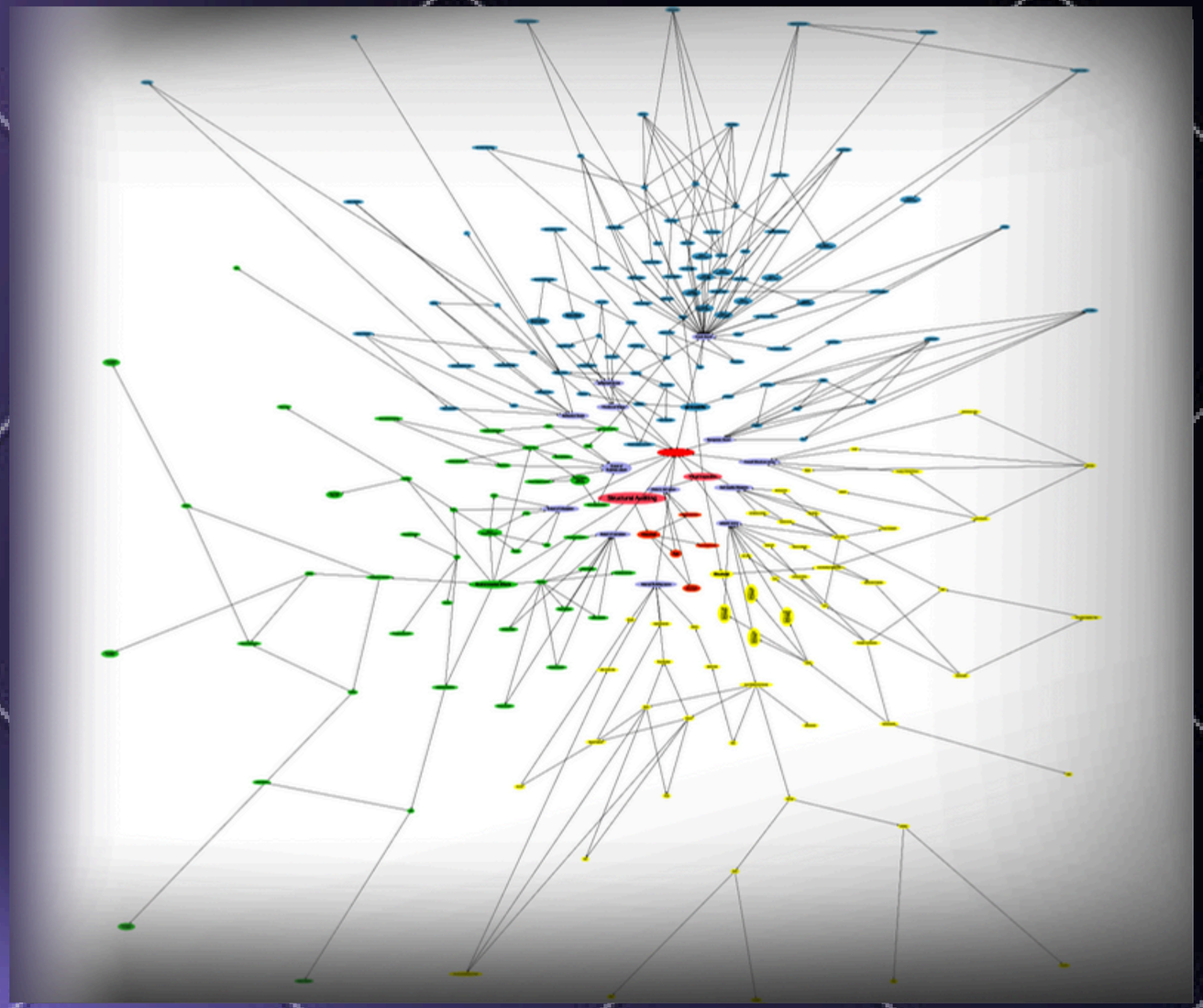
AFFORDABILITY

Often many of unrequired NDT tests are listed which decrease the affordability of auditing. These tests can be priced up to Rs. 20,000 per unit

Knowledge Model

1. Components of Model
2. Input Parameters
3. Mathematical Aspect
4. Illustrative Example

Overview of Knowledge Model



243 TOTAL PARAMETERS

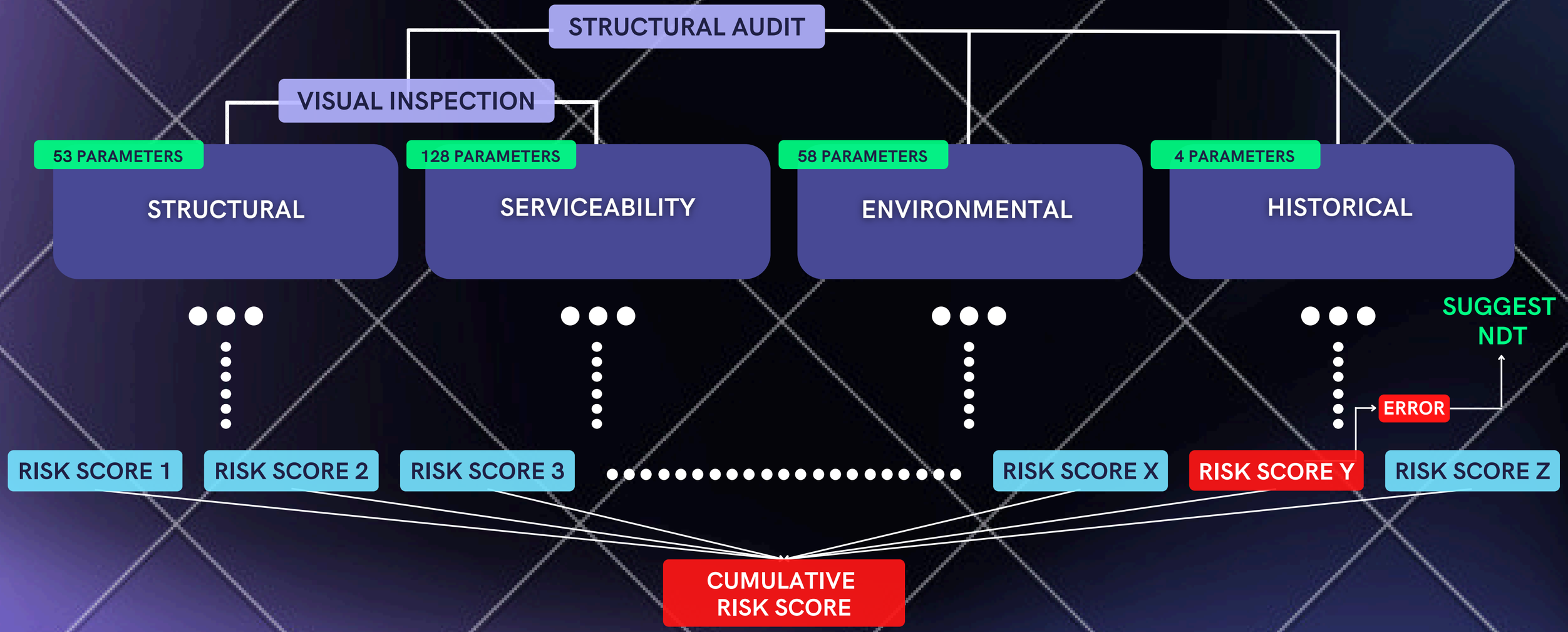
4 BUCKETS

14 SUB-BUCKETS

14 RISK SCORES

Components of our Model

Overall Structure and bucketing of parameters



Input Parameters

BUCKET	DESCRIPTION	PARAMETERS
STRUCTURAL	The structural tree of the graph is classified into extent of displacement, seismic score, internal building and overall structure. It compasses the structural component of buildings including the building materials, types of substructures and physical capacities	Soil Conditions Geometry and Setbacks Surrounding Vegetation Openings, Reinforcement Beams, Columns, Walls
SERVICEABILITY	Here we analyze the building for the presence of various damages and some visual observations which might be the indication of some further internal damage to the building. This tree of the graph is further classified into cracks, dampness, settlement, vibration and deflection	Vibrations and its effects Inter Storey Concurrencies Crack measurements Type and location of crack Settlement and DPC
ENVIRONMENTAL	Here we try to gauge the effect of surrounding environment on structure. The environment subsection of the tree is classified into extent of corrosion, extent of sulphate attack, extent of infestation etc.	Displacement of Structure Humidity and Corrosion Temperature Fluctuations Sulphate Attacks
HISTORICAL	The historical subsection of the tree is classified into age, rating of land history, when was the last renovation, score during last audit, and other factors that are related to structure's past	Age and Rating of land Time of last audit Score in the last audit

Mathematical Aspect

Probabilities and Bayesian Modelling

THE ROLE OF DOMAIN EXPERT

The knowledge model was split into four separate buckets. We devised the risk factor with the help of various academicians, structural auditors, and architects (the measure of severity of each parameter and its overall impact in determining the health of the building). To obtain the final risk score, a user (again, a domain expert) will manually input their measured values into the model and suitably set the probabilities (keeping the severity factor constant)

MATHS BEHIND RISK SCORES

BUCKET RISK SCORE

$$p_{bucket_{(j)}} = \sum_{i=1}^{k} \alpha_{ij} \cdot p_{ij}$$

CUMULATIVE RISK SCORE

$$\sum_{j=1}^{n} w_j \cdot p_{bucket_{(j)}}$$

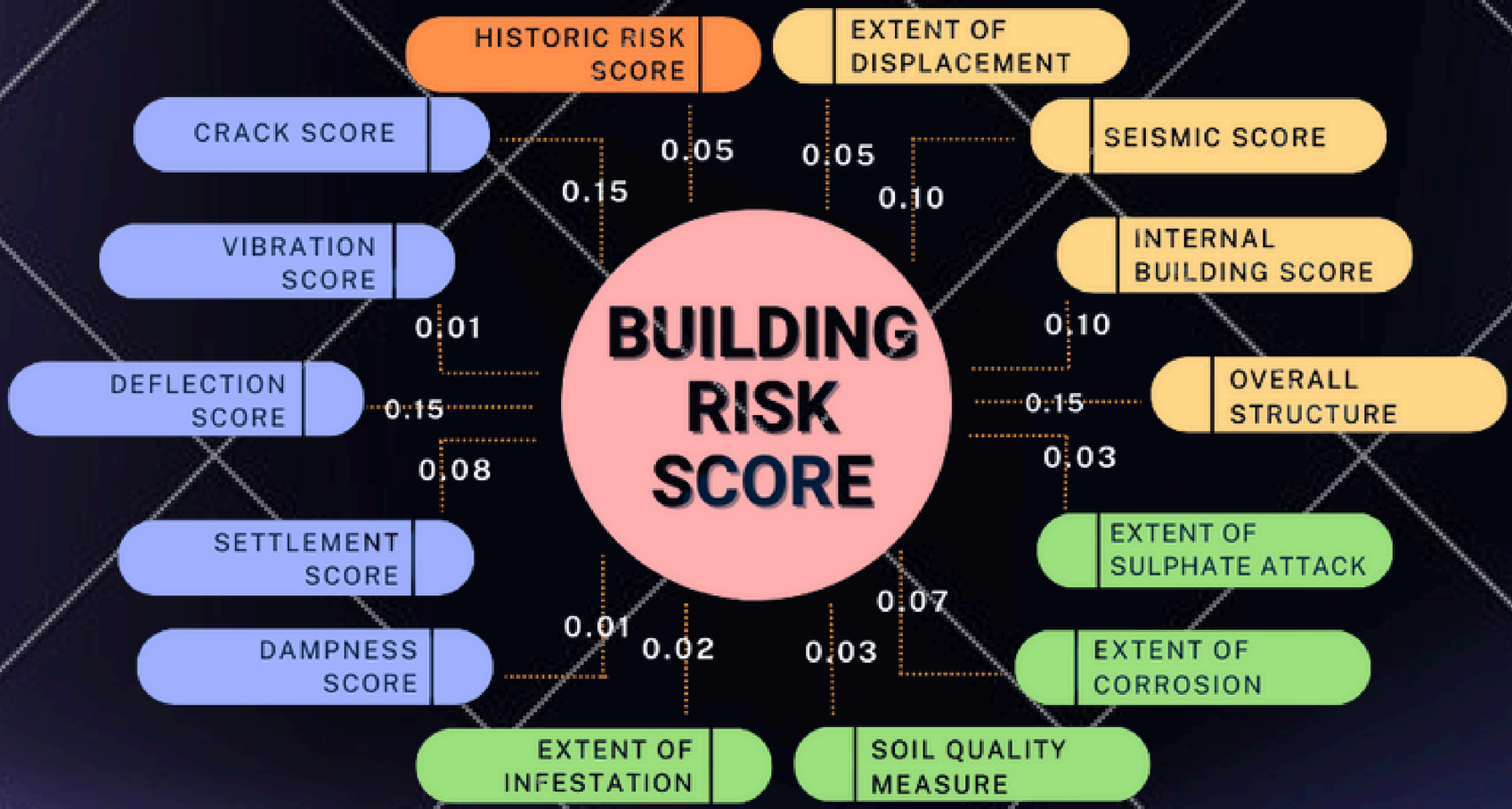
INTERPRETATIONS AND HELP IN DECISION MAKING

The bucket risk score indicates the severity of individual parameters, while the overall score determines the current risk level of the building as a whole. The next step is to determine the urgency of repairs from the recommended thresholds and conduct detailed Non-Destructive Tests to investigate the issues further

THRESHOLD	CONCLUSION
0.75 - 1.00	ACUTE STRUCTURAL DAMAGE
0.50 - 0.75	MODERATE STRUCTURAL DAMAGE
0.25 - 0.75	MINUTE STRUCTURAL DAMAGE
0.00 - 0.25	BUILDING IN GOOD CONDITION

Mathematical Aspect

Risk Score Interdependencies



Illustrative Example

Demonstration of Model in real world scenario

Positive Factor

Negative Factor

HISTORICAL DATA — 7/10

- Land History Rating (+)
- Previous Inspection History (−)

SULPHATE ATTACKS — 8/10

- White Salt Deposits (−)
- Lumpiness and Doming (−)

VIBRATIONS — 7/10

- Vibration frequency on Ground Floor (−)
- Vibration frequency on 6th Floor (−)

OVERALL STRUCTURE — 4/10

- Building Setbacks (+)
- Stiffness of Columns (+)

DISPLACEMENT OF STRUCTURE — 2/10

- Soil Conditions (+)
- Settlement (−)

DAMPNESS — 8.5/10

- Dampness rating of basement (−)
- Dampness rating of 7th floor (−)

DEFLECTION — 8/10

- 1^{o} internal deflection on 6th and 7th floor (−)
- 2^{o} total external deflection (−)

SEISMIC ZONE PROPERTIES — 2/10

- Seismic Coefficient (+)
- Bearing capacity (+)

CORROSION — 9/10

- Inter granular Corrosion (+)
- Stress Corrosion (−)

CRACKS — 9/10

- Crack Risk on 6th Floor (−)
- Closeness to Moisture (−)

SETTLEMENT — 7/10

- Width to Depth Ratio (+)
- Soil Excavation Rate (−)

INTERNAL BUILDING CHAR. — 6.5/10

- Column and Beam Rating (+)
- Wall Material on 3rd and 8th Floor (−)

Illustrative Example

Demonstration of Model in real world scenario

MAJOR DOMAINS

1. **HISTORICAL DATA** — No prior audits or renovations in building's life led to tthe possibility of damage and defects in the building — **7/10**
2. **ENVIRONMENTAL DATA** — A majority of parameters were deemed okay. Damages might be because of stress corrosion, heat affect of machinery and lumps — **5.5/10**
3. **SERVICEABILITY DATA** — Dampness and cracks were majorly found on the upper floors. 6th and 7th floors need instant repair — **8/10**
4. **STRUCTURAL DATA** — Soil was in good condition. Structure has an average integrity score. Material of walls needs to be looked at on 3rd and on some higher floors — **5/10**

Overall Risk Score

6.2 / 10

SUGGESTIONS

- Check foundation strength of lower floors
- High risk on 6th and 7th floors, need to be renovated within 6 months
- Further assess cracks on each floor and fix accordingly
- Possible leakage on 7th floor, fix immediately
- Take measures to prevent further leakage
- Better heat isolation on ground floor

Business Study

Feasibility Analysis

TECHNICAL

It is a technically workable model, which is easy to use for the consumer given the chatbot that Cognitive Garage provides. Users and stakeholders will be confident to use the model, since it would be based on inputs from the domain expert

ECONOMIC

With the increasing need of such safety checks, and the decreasing number of people in the industry, our model would become more and more economically feasible with time

LEGAL

While the model is in-line with the laws currently, more such laws will be developed given the need of regulations in the current industry, making our model more viable

ORGANIZATIONAL

The model would initially be set-up with a start up to deal with the technical and business parts. Initially domain experts and consultants will be required to develop the model as accurately as possible

Business Study

Scalability

Future Scope in the industry

Government Regulation and Reforms

Description

In the future, we can integrate IOT sensors with our model. The visual inspection can be replaced with various Computer Vision technologies. This would further increase the application in the absence of auditors in emergency situations

India's infrastructure severely impedes its economic progress. Hence, To close the present infrastructure gap, The government has become bullish towards infrastructural spending

- Target for infrastructural expenditure in 2022-23 was increased sharply by 35.4%.
- The infrastructure-related operations account for 13% of the total FDI inflow

- The government launched numerous housing reforms, such as the "Pradhan Mantri Awas Yojana" and "Smart Cities Mission"
- It estimates $1.5 trillion in infrastructure investments over the following ten years

Business Study

Targeted Users

COGNITIVE GARAGE

Commercial

Hazard assessment specialists hired by insurance companies can use the model to effectively evaluate the monetary value and the life of the building.

Residential

Structural auditors and building inspectors can use the model to effectively audit the entire building in time even with a limited number of equipment. It can also help to analyze the situations quickly.

Industrial

Risk factor of mines, power plants and other industries can be calculated effectively. Not only that, during any natural disaster like an earthquake, we can use it for quick assessment for effective evacuation and relocation.

Conclusion

- Our use case aims to make the process of inspection and maintenance more affordable to decrease casualties when a tragedy strikes
- The solution proposed by us strives to prevent the loss of lives through immediate, rapid, and objective analysis and take timely measures to strengthen the infrastructures
- With incoming Government mandates, and inclusion of IOT sensors in everyday life, our solution will revolutionise a sector that has shortage of people and deals with human life

THANKYOU