

臺日茶產業智慧應用趨勢研討會暨 第七屆臺茶葉技術交流會

茶樹栽培管理專家診斷系統的建立

中興大學農藝學系 郭寶錚

2025/07/29

地點:臺灣客家茶文化館

Development of Expert Diagnosis System for Tea Cultivation Management

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Topics

- **Related Background**
- **System Development Goals**
- **System Architecture and Important Concepts**
- **Concluding Remarks**

Factors Affecting Tea Production

- **Biotic**

- Diseases, Pests, Weeds, ...

- **Abiotic**

- **Soil (pH, compaction, moisture, salinity, ...)**

- **Nutrients (deficiency, overdose/toxicity)**

- **Climate (light, temperature, humidity, rainfall, ...)**

- **Management (genetic, planting density, fertilization, irrigation & pruning practices, pest management, ...)**

- **...**

Plantix <https://plantix.net/en/>



App Library News Company Business

Get the app

#1 FREE app for crop diagnosis and treatments

Download Plantix



1.7 sec

Get your crop diagnosed in 1.7 sec.



82

You'll be able to detect 82 different kinds of crops!



780

Find the right treatment for more than 780 diseases.



90%

Farmers report an improvement in their farming of 90%.



What caused it?

Root Development?

Deficiencies may occur because of low reserves of potassium in the soil or limited availability to the plant. Soils with low pH and sandy or light soils with little organic content are prone to nutrient leaching and drought, and may, therefore, cause problems. Heavy irrigation and high rainfall wash the nutrients from the root zone and can also lead to deficiency. Hot temperatures or drought conditions block the transport of water and nutrients to the plants. High levels of phosphorus, magnesium, and iron can also compete with potassium.

Potassium plays an essential role in the transport of water, the firmness of tissues and the exchange of gases with the atmosphere. The symptoms of potassium deficiency are irreversible, even if potassium is later added to the plants.

Development Goals



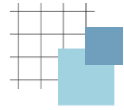
Human
Expert



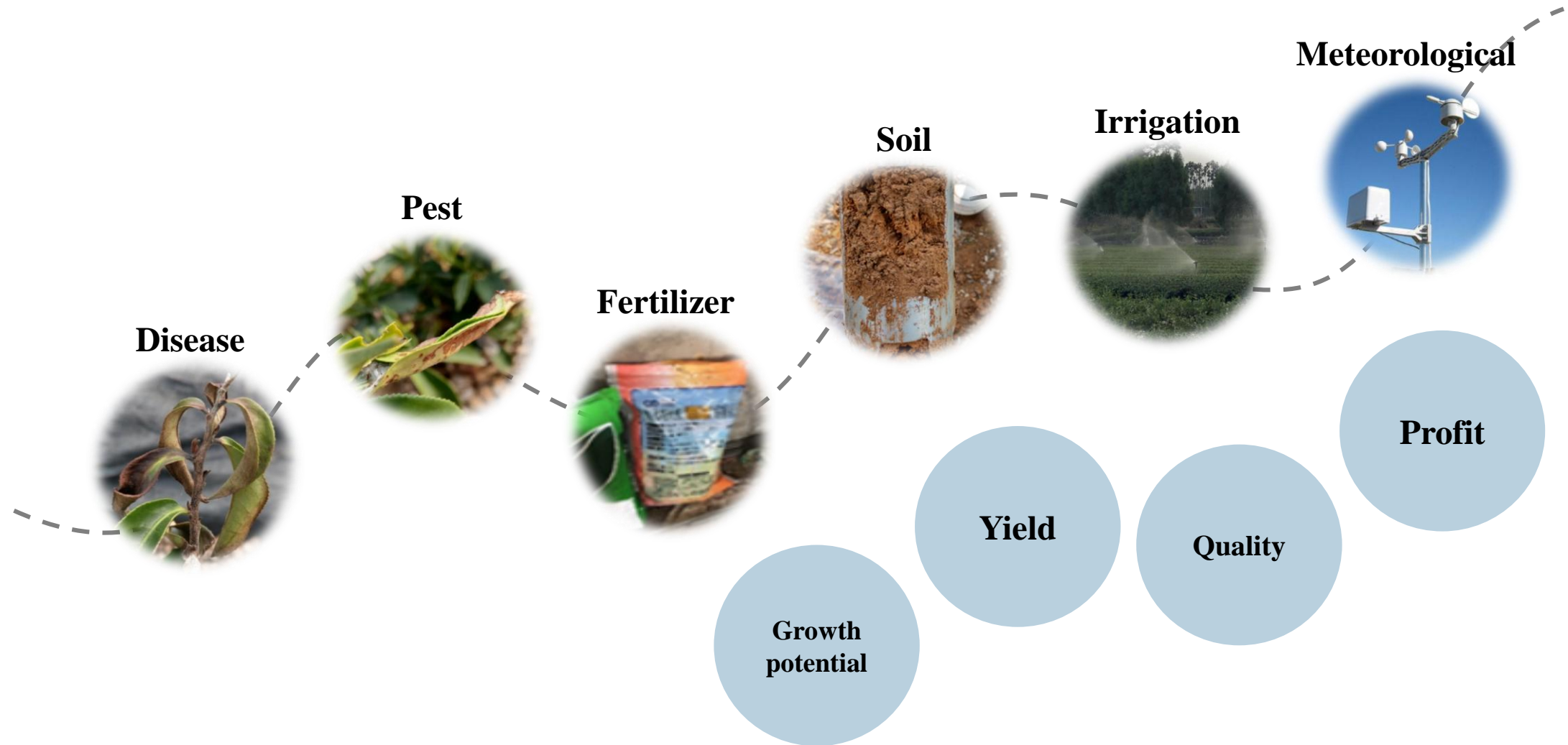
- Expert Expertise?
- Expert Availability?
- Expertise Preservation?
- New Experts Training?

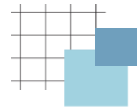


User
(lay not be an expert)

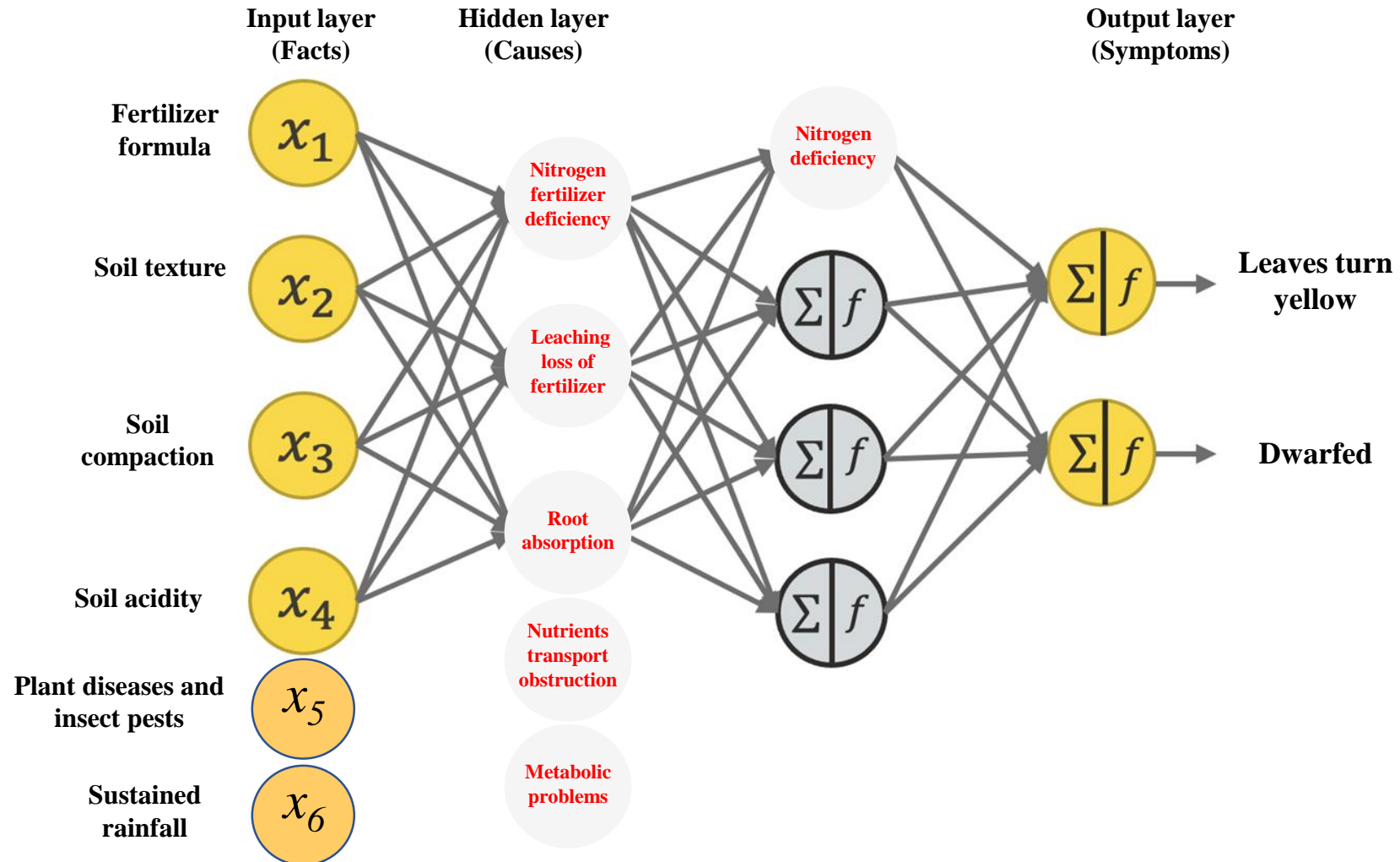


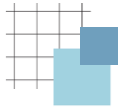
Factors That Affect Tea Growth





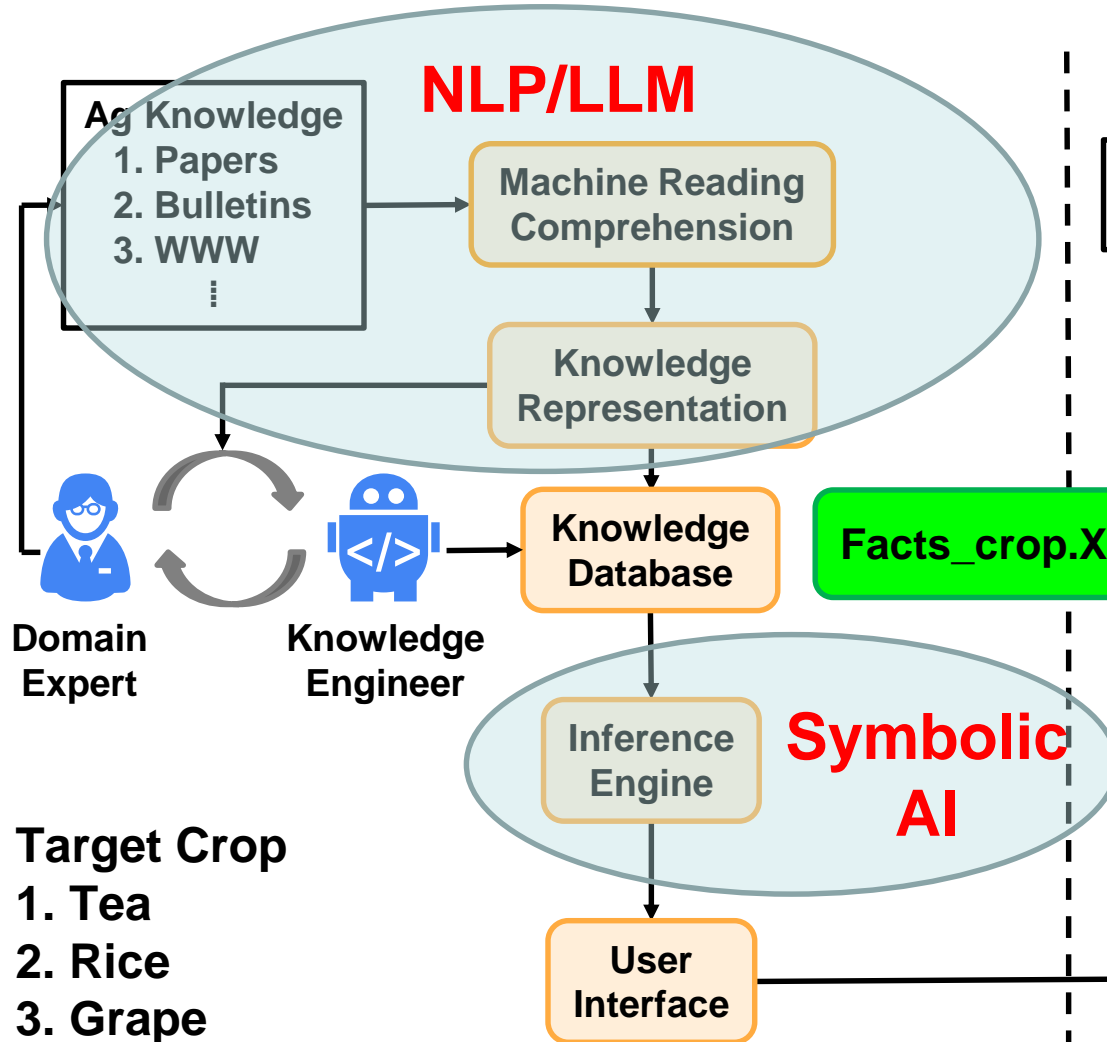
Main ideas about our system



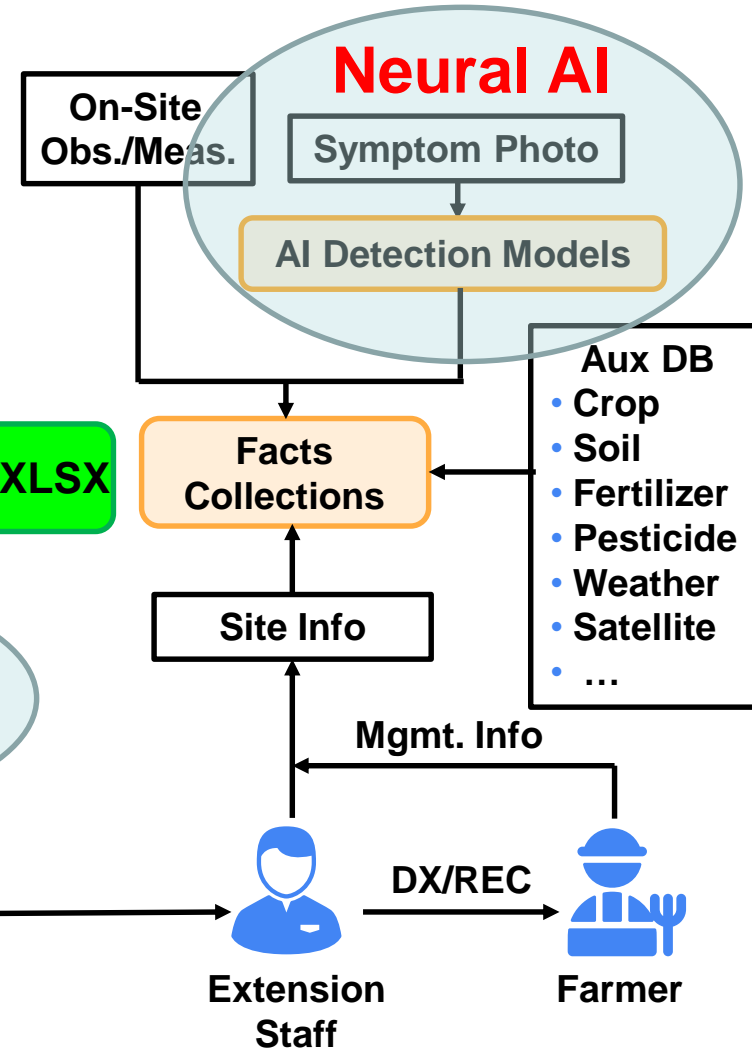


System Architecture

Development of expert diagnosis system



Survey in the field





Rule Based ES

Diagnosis Rule

IF (Symptom) THEN (Potential Problem), CF

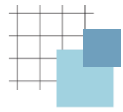
Recommendation Rule

IF (Potential Problem) THEN (Recommendation), CF

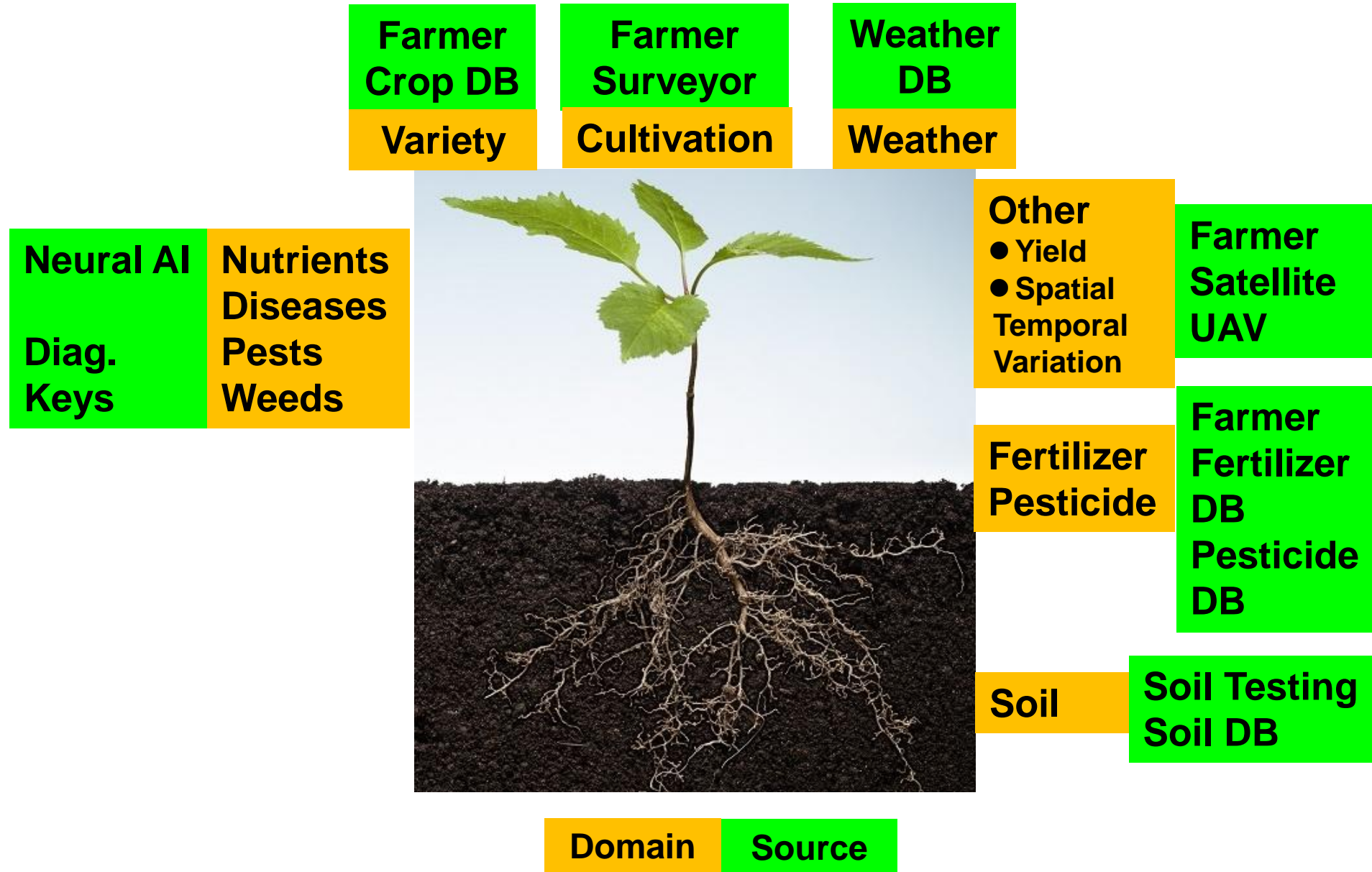
Fuzzy Logic

AND : MIN()

OR : MAX()

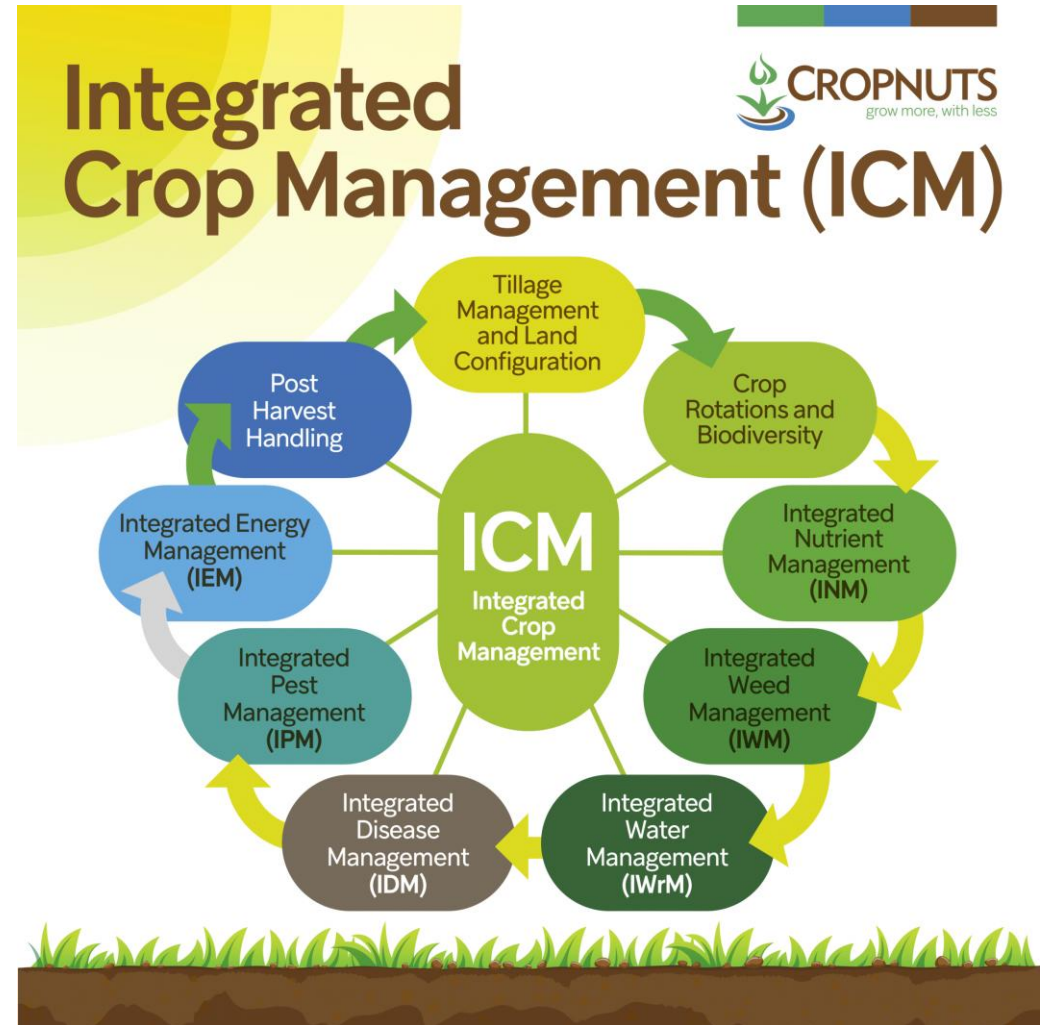


Diagnosis Domains



Recommendation Domains

- Variety Choice
- Soil Mgmt.
- Fertilization
- Cultivation
- Disease/Pest Mgmt.
Chem-Control
Phys-Control
Bio-Control
- Weed Mgmt.
- Meteorol. Disaster Prot.



<https://cropnuts.com/>



Vecteezy.com

2021/11-2023/11

ES5



uxwing

2023/12



Abilities Already Possessed

- Powerful computing power and memory capacity



- Visual ability to identify crop symptoms



Plantix
+
AI Models
Developed

- Know crop characteristics



- Know local soil properties



農業部
農業試驗所
Taiwan Agricultural Research Institute,
Ministry of Agriculture



Harmonized
World Soil
Database
version 2.0

- Know brands and ingredients of local fertilizers/pesticides



農業部農糧署
AGRICULTURE AND FOOD AGENCY,
MINISTRY OF AGRICULTURE

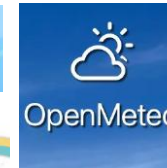


農業部動植物防疫檢疫署
ANIMAL AND PLANT HEALTH INSPECTION AGENCY
MINISTRY OF AGRICULTURE

- Know local weather and climate



氣象資料開放平臺
OPEN DATA



OpenMeteo



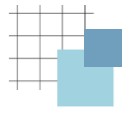
Global
Historical
Climatology
Network daily
(GHCNd)

- Know spatial temporal variation of crop status

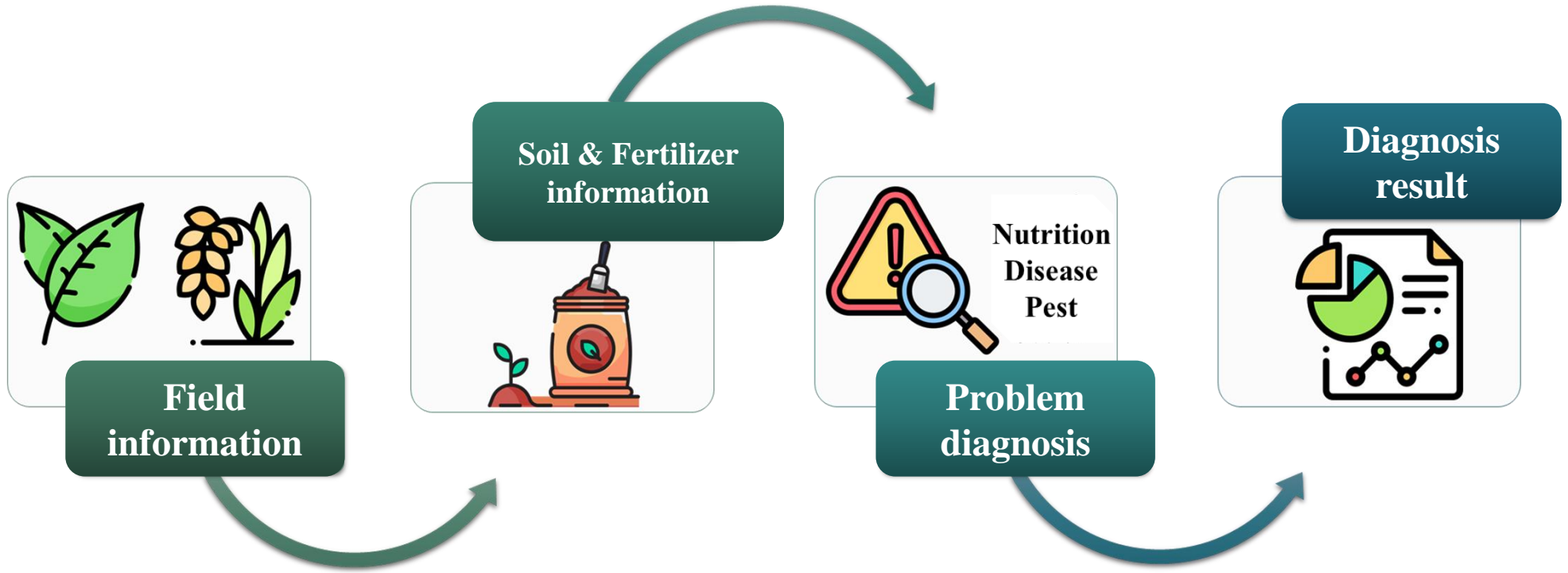


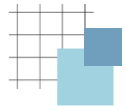
- Can communicate in multiple languages





System Diagnosis Process



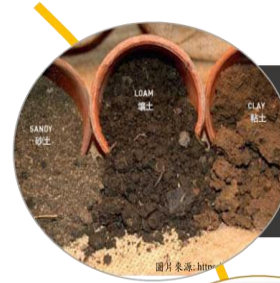


System Display (web page)

Site Info
Field Info ▾
Historical Info ▾
Crop Symptoms ▾
Expert Diagnosis ▾
Logout

Site ID: 100-1-00004 Site Name: Urlong_Tea_factory

Crop	Select Crop ▾
Cultivar	Cultivar (select crop first) ▾
Planting Date	YYYY-MM-DD
Farmer Name	Select or Enter Farmer Name
Contact Phone	Select or Enter Contact Phone
Site Name	Select or Enter Site Name
Site Location	Longitude (+/-) / Latitude (+/- #)
Photo Positioning	



Soil information



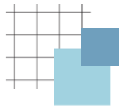
Fertilizer and pesticide application information



Problem diagnosis
(about disease, pest and nutrition)



History data
(about satellite and meteorological)



Field Information



Site Info Field Info ▾ Historical Info ▾ Crop Symptoms ▾ Expert Diagnosis ▾ Logout

Site ID: 100-1-00004 Site Name: Urlong_Tea_factory

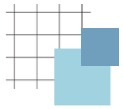
Crop	Select Crop	▾
Cultivar	Cultivar (select crop first)	▾
Planting Date	YYYY-MM-DD	
Farmer Name	測試茶	
Contact Phone	0987456321	
Site Name	請選擇坵塊	
Site Location	Longitude (+/- ###.#####)	/ Latitude (+/- ###.#####)
Site Boundary	選擇檔案	未選擇任何檔案

◆ **Field basic information input.**
◆ **Crops, variety, age of tree, farmer contact information and field coordinate.**

Search by Location

Download Site Boundary

Confirm



Soil Information



Site Info **Field Info** ▾ Historical Info ▾ Crop Symptoms ▾ Expert Diagnosis ▾ Logout

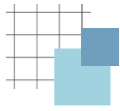
Site ID: 218-1-00001 Site Name: Testing tea The temporary storage data has been read!

DB Used	<input checked="" type="radio"/> Soil Database, TARI (Taiwan) ▾ <input type="radio"/> HWSD v2.0, FAO
Soil Classification	Red soil ▾ Select HWSD V2 category ▾ Select ST 13th category ▾
Soil Texture	clay loam ▾
Mottling Depth (cm)	Please Enter (cm)
Penetration Depth (cm)	Please Enter (cm)
Soil Acidity	6.3 ▾
Calcareous	Lime-free ▾
Electrical Conductivity (m	Please Enter (Saturated mS/m)
Organic Matter (%)	3.5 ▾
Available Phosphate (ppr	Please Enter (ppm)
Available Potassium (ppn	Please Enter (ppm)
Surface Cover/Mulching	Select the surface covering/covering condition ▾
Planting Position	Select a plant location ▾
Microtopography	Please Select ▾

◆ Soil information input.
◆ Soil classification, soil texture, mottling depth, penetration depth.

◆ Soil acidity, calcareous, electric conductivity, organic matter, available P and available K.

◆ Surface cover/ mulching, plant position and micro topography.



Fertilizer Application Information

Site Info Field Info Historical Info Crop Symptoms Expert Diagnosis Logout

Site ID: 218-1-00001 Site Name: 測試茶 The temporary storage data has been read!

Select Fertilizer Open Data, AFA (Taiwan)

N P K Ca Mg OM

Brand Name	Brand Name (combo box)
Rate	Kg/ha
Timing	Base fertilizer
Method	sprinkle application

Add

Fertilizer Composition

N	N(%)	P	P2O5(%)	K	K2O(%)
Ca	CaO(%)	Mg	MgO(%)	OM	OM(%)

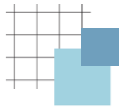
Reg Num Registration Number (combo box)

Fertilizers Applied

Brand Name	Rate	Timing	Method	Edit
農友牌台肥寶效39號有機質複合肥料	60	夏肥	灑施	
鈣讚硝酸鈣	60	基肥	灑施	

◆ Fertilizer information input.
◆ Names of fertilizers used, rate (Kg/ha), timing, and application method

Confirm



Pesticide Application Information



Site Info Field Info Historical Info Crop Symptoms Expert Diagnosis Logout

Site ID: 218-1-00001 Site Name: 測試茶

Select Pesticide Open Data, APHIA (Taiw) ▾

Category	fungicide ▾
Target	Fine mites ▾
Brand Name	超蟎益
Date	YYYY-MM-DD
Rate	Application Rate Kg(L)/ha
Ratio	Dilution Ratio
Times	Application Times
Interval	Interval (days)

Add

Pesticide Info

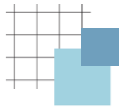
Rate	2.5 Kg(L)/ha
Ratio	400
Times	Application Times
Interval	Interval (days)
Safety Period	Safety Period (days)

Pesticides Applied

Brand Name	Date	Rate	Ratio	Times	Interval	Edit
勝蟎	2024-04-02	0.5	2000	1	0	
富吉安	2024-02-06	0	2000	1	7	
祥安心	2024-02-06	0	400	1	7	

- ◆ Pesticide information input.
- ◆ Names of pesticide used, application date, rate (Kg/L per hectare), dilution ratio, application times, and interval days

Confirm



Observation of Meteorological Data

Site Info Field Info Historical Info Crop Symptoms Expert Diagnosis Logout

Site ID: 218-1-00001 Site Name: 測試茶

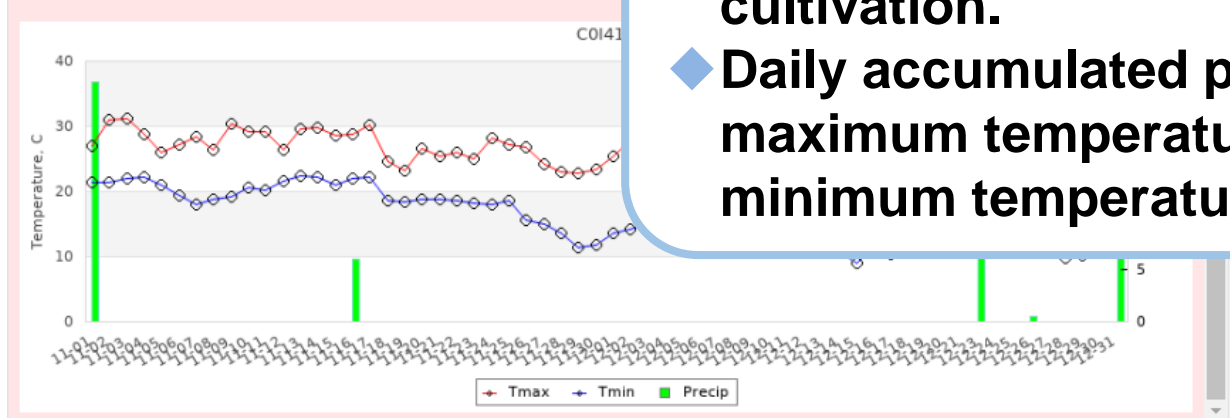
Date Start: 2024-11-01 Date End: 2024-12-31 Item: Rainfall Temperature Search Database

DB Used: CWB Daily (Taiwan) Open-Meteo Search Radius: 10 Km

Threshold Settings for Stresses

Base T	10	°C	Heat Stres	30	°C/	4	Hr	Cold Stres	5	°C/	4	Hr
Too Wet	90	%/		4	Hr	Too Dry	50	%/	4	Hr		
Rainy TH	1	mm	Contd Rai	10	day	Rain Dama	50	mm/	3	日		
Foehn	35	°C/	50	%/	2	Hr	Over ET	15	Pa	3	Hr	

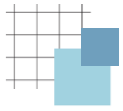
COI410	名間	名間鄉董門巷2號(名間鄉立體停車
COG880	二水	二水鄉文化村119號(二水國小)
COI460	南投	南投市龍泉里玉井街5號(南投市公



- ◆ Meteorological data for monitoring climate conditions affecting tea cultivation.
- ◆ Daily accumulated precipitation, daily maximum temperature and daily minimum temperature.

Experienced high temperature and low humidity environment

Confirm Cancel



Observation of Satellite Data

◆ Draw the changes of NDVI and NDWI under different time and space.

◆ NDVI: Normalized difference vegetation Index

◆ NDWI: Normalized difference water index

[Site Info](#) | [Field Info](#) | [Historical Info](#) | [Crop Symptoms](#) | [Expert Diagnosis](#) | [Logout](#)

Site ID: 100-1-00002 Site Name: A

Date Start	2024-02-11		Date End	2025-02-11		Image Interval >=	20		Days	Search Database		
<input checked="" type="checkbox"/> NDVI	<=	0.2	<=	0.4	<=	0.5	<=	0.6	<=	0.85	<=	1.0
<input checked="" type="checkbox"/> NDWI	<=	0.1	<=	0.15	<=	0.2	<=	0.25	<=	0.3	<=	1.0
<input checked="" type="checkbox"/> SRVI	<=	2	<=	3	<=	4	<=	5	<=	8	<=	10

ST-Analysis Settings (consistent area)
NDVI >= 0.5
CV <= 0.3
High >= 1.05
Low <= 0.95

	NDVI		NDWI		SRVI	
区块名稱	Max	Min	Max	Min	Max	Min
TMPP	0.823	0.296	0.362	-0.179	10.705	1.847

Image Analysis Indicates

NDVI

- Obvious temporal variation in the growth of tea trees
- Obvious spatial variation in the growth of tea trees
- Too many old leaves in winter (purple areas)
- Tea plantation with trees over 3 years old

NDWI

- Obvious spatial variations in the water content of tea trees
- Tea trees have suffered from water shortages (red area)
- Tea trees are irrigated too frequently (almost all blue areas)

SRVI

- Low fresh tea leaves yield

Confirm
Cancel

NDVI NDWI SRVI

20240212

20240830

20240313

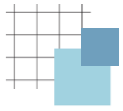
20241014

20240422

20241113

20240731

20241218



AI Recognition Model

Site Info Field Info Historical Info Crop Symptoms Expert Diagnosis Logout

Site ID: 218-1-00001 Site Name: 測試茶 The photo is finished!


Field Photos 選擇權限 20 個權限

Photo Type Close-Up Shot Close Shot Long Shot

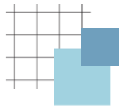
Upload Photos

Symptom	Degree	Confirm
Calcium deficiency	0.05	<input type="checkbox"/>
Magnesium deficiency	0.05	<input type="checkbox"/>
Japanese blister blight	1.00	<input type="checkbox"/>
Blister blight	0.08	<input type="checkbox"/>
Leaf miner	0.05	<input type="checkbox"/>

Possible Symptoms



- ◆ Uses AI analysis to detect possible symptoms in tea leaves.
- ◆ Displays predicted symptoms with confidence scores for user verification



Problem Diagnosis

Site Info Field Info Historical Info Crop Symptoms Expert Diagnosis Logout

Site ID: 100-1-00002 Site Name: A

Symptom Descriptions	Degree				
	1	3	5	7	9
There are small brown spots on the tender leaves, and the color becomes darker after expansion, and it becomes reddish brown	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The leaves have small yellow-green round spots	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The leaves have obvious concentric chakra patterns	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The brown spots extend inward from the edge of the leaf	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
leaves have insignificant light green reticular patterns	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
reticular white substance appears on the back of the leaf	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
white substance appears on the back of the leaf	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
leaf surface has irregular yellow halo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
diseased part of the leaf tissue curled to the leaf surface	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
tender leaves appear yellow, light green or light red round lesions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
leaf round yellow green lesions are sunken toward the back of the leaf	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
leaf withered yellow	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Typical Photos



NO IMAGE AVAILABLE

Prev Next

Symptom Explanation

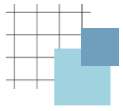
Symptom Description

array key 1 in expertsys5L\php\sy

Warning: Undefined array key 1 in C:\xampp\htdocs\expertsys5L\php\sy on line 125

◆ Rules for diagnosing plant nutritional disorder, diseases and insect pests.

Confirm Delete All



Output Diagnostic Results



Site Info Field Info ▾ Historical Info ▾ Crop Symptoms ▾ Expert Diagnosis ▾ Logout

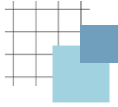
Site ID: 218-1-00001 Site Name: Testing tea **Diagnosis Completed!!** (If left blank, no diagnostic results are applicable.)

Diagnosis Results


Potential Problems	Confidence Level	Field Symptoms	Reason for Inference
Japanese blister blight	1.00	The leaves have insignificant light green patterns	
Blister blight	1.00	White substance appears on the back of the leaves	
Soil too much calcium	0.90	There are discarded space bag residue	Red soil It is usually acidic, but the calcium content in the mushroom space bag is high. If the abandoned mushroom space bag has been applied, it will affect the growth of young plants.
Nitrogen fertilizer is insufficient	0.90	Field area nitrogen application amount is lower than the recommended application amount	
Phosphorus fertilizer is insufficient	0.90	Field area phosphorus anhydride application amount is lower than the	

◆ **Diagnosis results identify potential problems and corresponding field symptoms.**

Show Recommendations



Suggested Actions for Plant Health Improvement

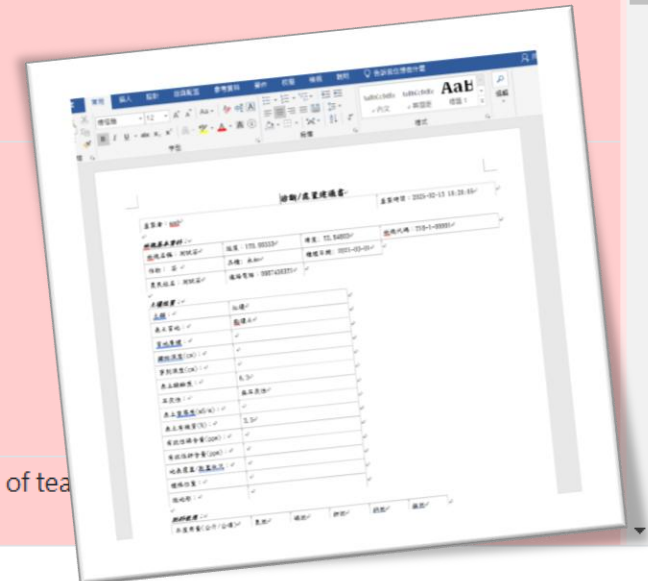

[Site Info](#)
[Field Info](#)
[Historical Info](#)
[Crop Symptoms](#)
[Expert Diagnosis](#)
[Logout](#)

Site ID: 218-1-00001 Site Name: Testing tea

Improvement Recommendations

Problems Dealt	Practices Recommended	Confidence Level
Netcake disease	Plant disease resistant varieties, such as Qingxin Dawu, Taicha No. 13, etc., do not plant the disease-sensitive varieties Qingxin Wulong.	1.00
(Red leaf blight, cake disease, round spot disease, soot disease, algae)	Reduce the humidity in the tea garden.	1.00
(Red leaf blight, cake disease, round spot disease, soot disease, algae spot disease, algae, branch blight)	Clear the field...	
(Red leaf blight, cake disease,	Reference Plant Protection Information System (https://otserv2.tactri.gov.tw/PPM/), content of tea Perform the medicine.	

◆ **After the diagnosis, users can download the report.**



Download Diagnostic Report

India Field Verification

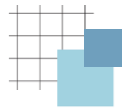
Location: Shillong, Meghalaya

(a,b) Urlong tea estate with two plantations.

(c-e) Anderson tea estate plantation.

(c,f) Introduce and show the Tea Expert System.

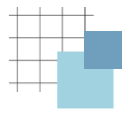




Field Validation Result in India

- **Narayanpur Panbarry Tea Estate** is a lowland tea plantation. It mainly grows large-leaf tea for black tea production.
- In the Jorhat region, shade trees are required for tea plants due to the extreme summer heat.
- According to field observation and image data, local tea diseases have been successfully diagnosed.
- About **750 images** of tea pests and diseases from India have been collected and are currently being analyzed with the help of experts in Taiwan.
- This effort contributes to building a localized dataset of tea pests and diseases in India.





India Field Validation

- Attending Assam 2.0 Summit

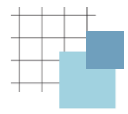
Attending India Assam 2.0 Summit at Guwahati

(a-c) Give a speech in Ayush, Tea, Flavour & Fragrance section.

(d) Sign MoU with the Secretary (Dr. Joydeep Phukan) of Tocklai Tea Research Institute.

(e,f) Visit Tocklai Tea Research Institute in Jorhat. (e) Discussion (f) Visiting Tea Factory.

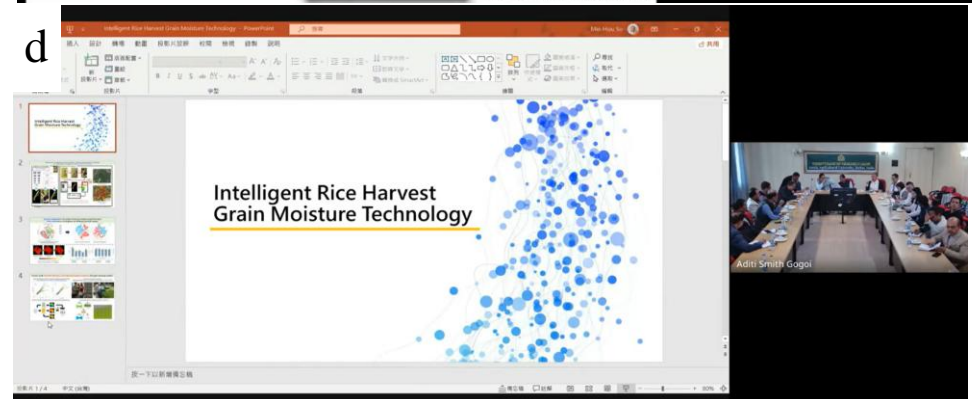
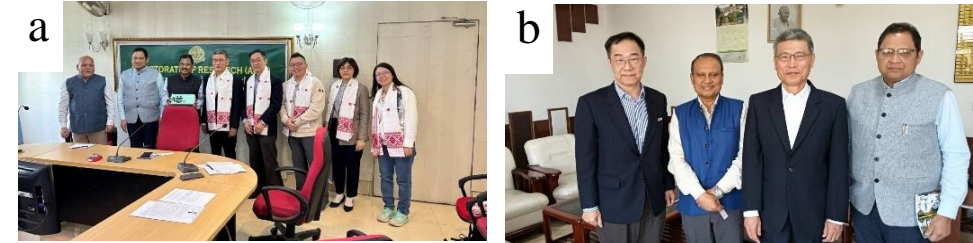


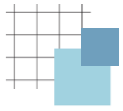


Visiting Assam Agricultural Univ. in Jorhat

(a,b) Photo with Vice Chancellor of AAU , Dean of Agricultural College and Head of Department of Tea Husbandry Technology.

(c,d) Introduce Tea Expert Diagnosis System for Tea Cultivation and Management to the faculties in Assam Agricultural University.

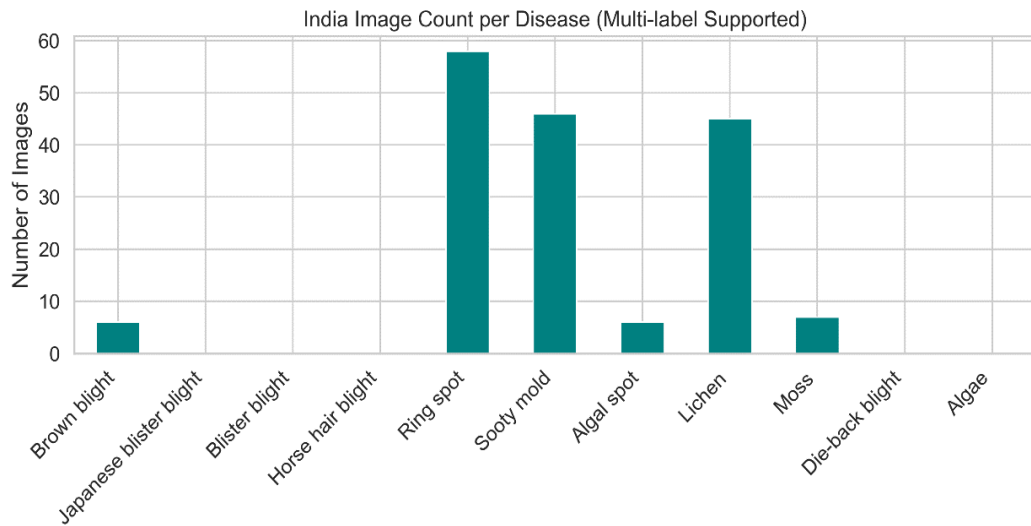




Field Validation Result

- As of May 31, 2025, a total of 231 images of tea pest and disease symptoms from Indian have been collected and added to the existing tea symptom dataset.
- After categorizing the images into four major domains -**diseases**, **pests**, **nutrient disorders**, and **others**-the dataset has reached a total of 10,420 images.

Sample Counts of Indian Tea Tree Disease Categories (Data as of May 31, 2025)



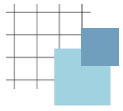
The updated tea disease image dataset contains a total of **3,510** images, including **163** images from India. The dataset will undergo quality filtering (n=3,081), and then be split into a training set (n=2,775) and a test set (n=306) in a 9:1 ratio.

Tea Tree Symptom Image Dataset and Number of Collected Categories

Symptom Image Dataset	Dataset size	Number of annotated images	Number of classes
Tea	10,382	14,349	Disease: 11 Pest: 33 Nutrition: 13 Other: 3

Performance metrics of the tea **disease** image recognition AI model Tea_Disease_v06.pkl, validated using the test set (n=306), across each disease category.

Chinese Name	Name	precision	Recall	F1 score	support
赤葉枯病	Brown blight	0.7857	0.5238	0.6286	21
網餅病	Japanese blister blight	1	1	1	23
餅病	Blister blight	0.9868	0.9868	0.9868	76
茶髮狀病	Horse hair blight	0.98	1	0.9899	49
輪斑病	Ring spot	0.8182	0.75	0.7826	36
煤煙病	Sooty mold	0.9048	0.8636	0.8837	22
藻斑病	Algal spot	0.8654	0.7895	0.8257	57
地衣	Lichen	1	0.7778	0.875	27
苔癬	Moss	1	0.75	0.8571	4
枝枯病	Die-back blight	1	0.5	0.6667	2
藻類	Algae	0.9091	0.7692	0.8333	13



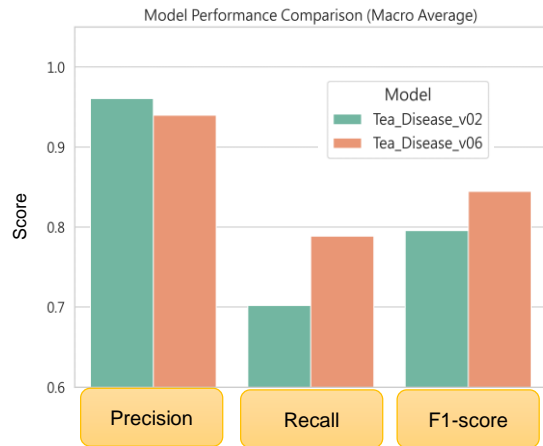
Field Validation Result

AI model Accuracy evaluation

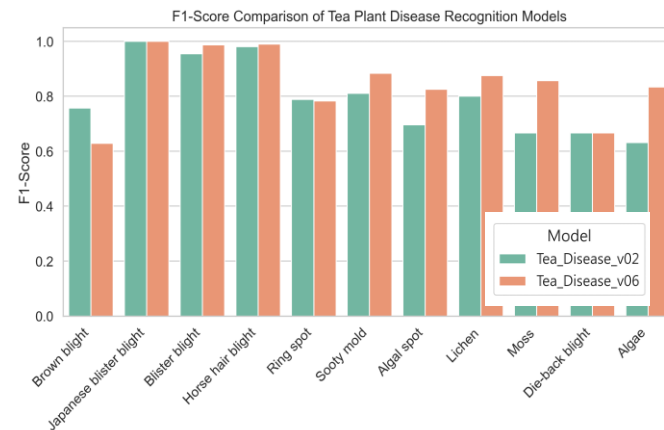
Tea_Disease_v06.pkl	including field images from India and Taiwan
Tea_Disease_v02.pkl	including field images from Taiwan

Validation using the test set (n=306) to evaluate two tea disease image recognition AI models.

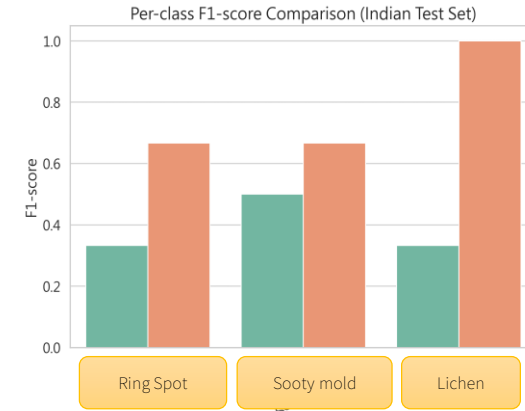
Overall Model Performance Comparison



Per-Class F1-Score Comparison of Tea Disease Recognition Models

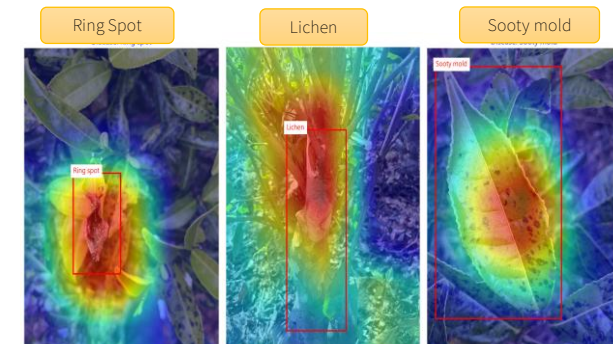


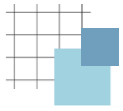
Comparison of Two Models on Indian Tea Disease Images



Analysis of the difference in F1 score performance between the two models on images of various tea disease categories from Indian tea trees in the test set (n=3-5 per category).

Model Attention Visualization using Grad-CAM

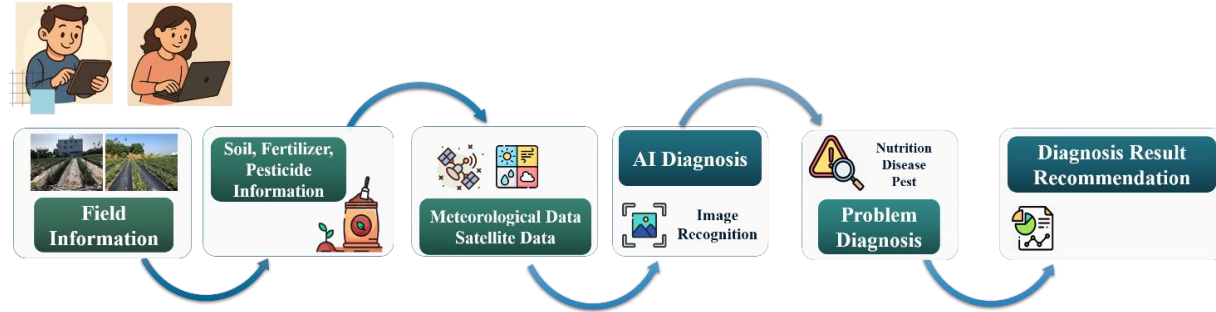




Field Validation Result

User Experience & Feedback

System Diagnosis Process



Survey Respondents and Feedback Summary

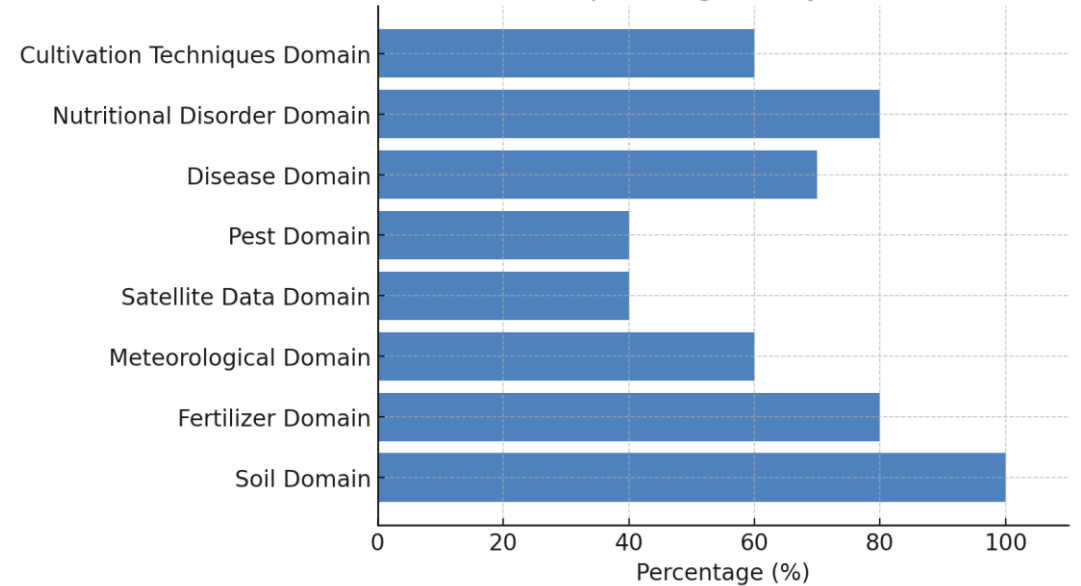
- ✓ Target Audience:
 1. Number of second-year Master's students in the Plant Medicine and Good Agricultural Practice program: 11
 2. Number of Reserve Plant Doctors in the Plant Teaching Hospital: 2
- ✓ Number of Responses Collected: 5

➤ *Although the sample size is limited, all respondents possess relevant training or diagnostic experience, providing valuable insights*

Advantages of the User Feedback System

- ✓ Provides expert knowledge across multiple domains.
- ✓ Automatically load soil, weather, climate, and satellite data base on field location.
- ✓ The system has a clear and easy-to-use interface.
- ✓ Allows users to download reports easily for recordkeeping and sharing.

Domains Most Needed by Users in the Multi-Domain Expert Diagnosis System



Education

(Learning is endless)



Variety

Cultivation

Weather

Nutrients
Diseases
Pests
Weeds



Other
● Yield
● Spatial
Temporal
Variation

Fertilizer
Pesticide

Soil

Domain

Ways to Train the ES

- **Testing the ES at Various Sites**
 - Improvement of UI designs**
 - Arrangement of questions asked**
 - Correctness of typical photos displayed**
 - Accuracy of potential problems diagnosed**
 - Completeness of recommendations suggested**
- **Expand the Existing Knowledges**
 - Buildup Case Reports for Diagnosis Rules**
 - Increase AI Models for Photo Interpretation**

Concluding Remarks

- The stresses encountered by field crops are **numerous and complex**, but on-site diagnostic personnel are often **limited by training and experience**, making it difficult for them to conduct a comprehensive diagnosis in order to provide the best treatment recommendations.
- An expert diagnosis system can **collect and save** the knowledge and experience of experts in different fields, thereby assisting on-site diagnostic personnel to conduct a **comprehensive diagnosis** and provide the best treatment recommendations.
- The expert diagnosis system that has been developed is **a small step** towards the above ideal. Hope we can **collaborate** together to make the developed expert diagnosis system more perfect.

*Thanks for Your
Attention*