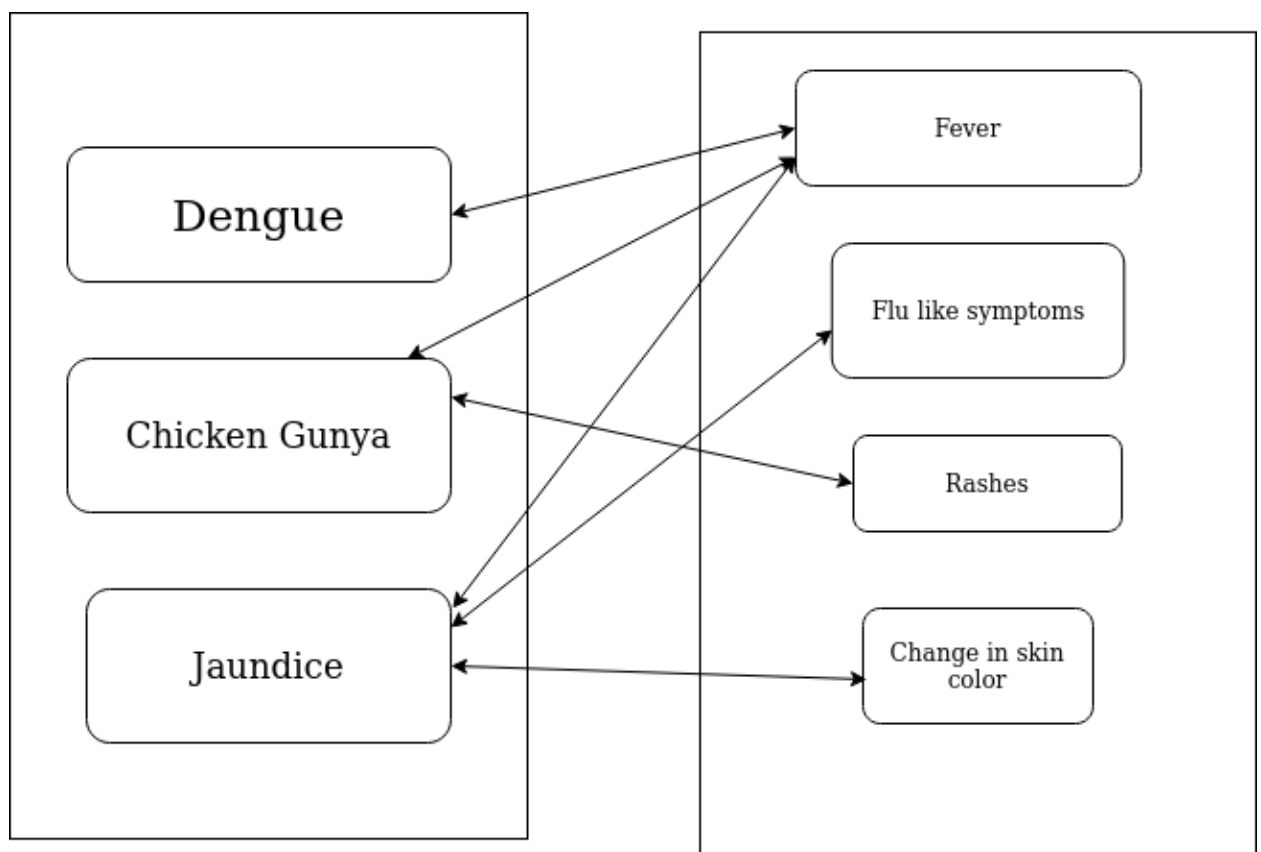


Crop Darpan Algorithm explained by an example.

Coming to basic terms used:

- 1) Problem and Symptom: Problems is a set of diseases for a given crop and Symptoms are visual descriptions of conditions a crop develops for a disease. The Relationship between Problems and Symptoms is many to many relationships.



So for a given disease, we can have a symptom set which has all symptoms that disease may show. And for a given symptom we can have a disease set (for example Jaundice: {Fever, Flu, Change in skin color} which tells about the symptom in list of all disease(eg: fever set: {Dengue, Chikungunya, Jaundice})).

- 2) Our current system has 3 levels of symptoms for all diseases. L1 symptoms which are various parts of plants and L2 symptoms deal

with the more precise symptom for a L1 symptom and so on. A given L2 can have only one L1 symptom as a parent and given L3 can have only one L2 parent. These are arranged in a hierarchical tree.

Fig:1

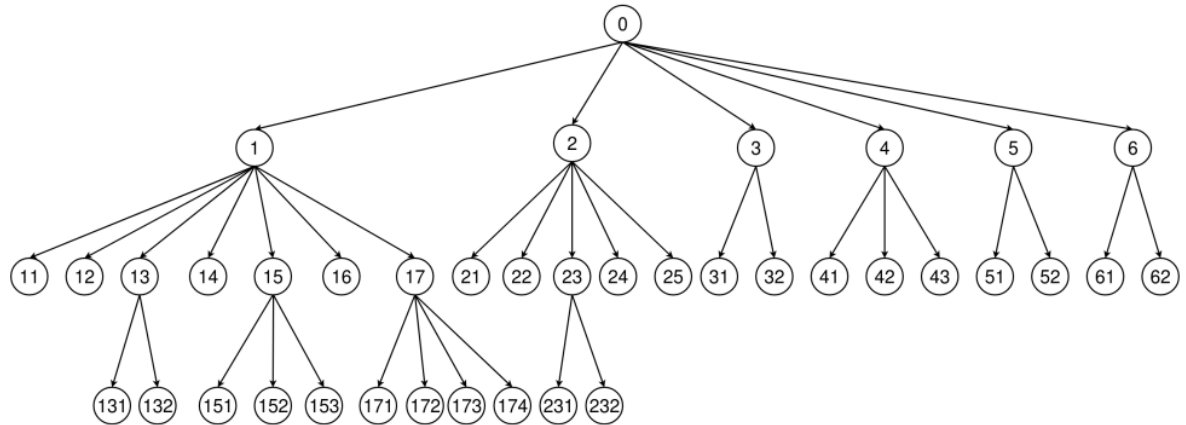


Figure 4.11: Illustrative example symptom-symptom relations (hierarchy)

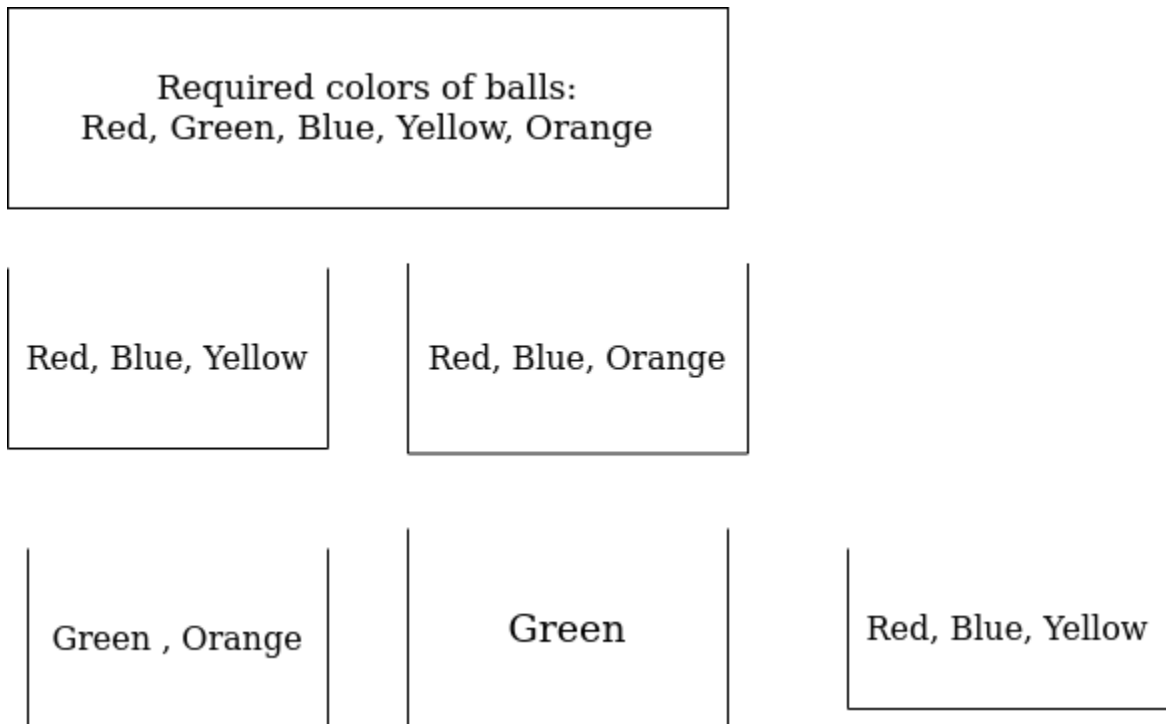
Here 0 root node corresponds to the Crop and 1,2,3,4,5,6 are L1 symptoms. 11,12 ,13 ... corresponds to L2 symptoms. 131,132,151, .. corresponds to L3 symptoms.

Below is a Symptom set for each disease. Likewise we can create Disease sets for each symptom. So as we see the table attached below, a disease has a set of symptoms which are either L1, L2 and L3 .

Table 4.6: Illustrative example problems-symptoms relation table

Disease	Symptoms
Pink bollworm	Bolls damage (2), Premature opening of bolls (21), Fed bolls but holes not visible (24), Presence of small and pink color larvae with brown head inside the boll (25), Flowers damage (4), Unopened and twisted flowers in rose shape (43), Shedding of flowers (42), Lint color change [5], Pink color lint (52)
Leaf hoppers	Leaves damage (1), Curling of leaves (13), Upward curling of leaves (132), Leaves color change (15), Reddening of leaves from margins (153), Spots on leaves (17), Brown necrotic patches on leaves (171)
Thrips	Leaves damage (1), Groups of small size larvae on the lower side of the leaf (14), Curling of leaves (13), Upward curling of leaves (132), Shiny silver color coating on the lower side of the leaves along veins (12)
Anthracnose	Leaves damage (1), Spots on leaves (17), Reddish circular Spots on leaves (172), Bolls damage (2), Premature opening of bolls (21), Spots on bolls (23), Small water soaked-circular-reddish brown depressed spots appear on the bolls (232), Stems damage (3), Splitting of stem and Shredding of bark (32), Lint color change (5), Black color of lint (51), Yellow or brown color of lint (53)
Bacterial blight	Leaves damage (1), Shedding of leaves (16), Stems damage (3), Lint color change (5), Bolls damage (2), Leaves color change (15), Blackening of veins in leaves (151), Splitting of stem and Shredding of bark (32), Oozing of gum over the stems (31), Black color of lint (51), Premature opening of bolls (21), Premature shedding of bolls (22), Spots on leaves (17), Reddish-brown color angular spots on both sides of leaves (174), Spots on bolls (23), Dark black irregular spots (231)
Boron deficiency	Flowers damage (4), Whole plant damage (6), Bolls damage (2), Drying of terminal buds (41), Bushy appearance of the plant (61), Premature shedding of bolls (22), Shedding of flowers (42)
Zinc deficiency	Leaves damage (1), Curling of leaves (13), Upward curling of leaves (132), Flowers damage (4), Shedding of flowers (42), Whole plant damage (6), Stunted growth (62)
Mites	Leaves damage (1), Bolls damage (2), Brittle leaves (11), Premature shedding of bolls (22), Premature opening of bolls (21), Groups of small size larvae on lower side of the leaf (14), Curling of leaves (13), Leaves color change (15), Spots on leaves (17), Shedding of leaves (16), Downward curling of leaves (131), Reddening of leaf from middle portion and drying (152), Yellowish spots on leaves (173)

- 3) Coverage set : Lets see this by an example. Let us consider we have 4 bags.



Our need is to collect red, Green, Blue, Yellow and Orange color balls and we need to figure out the minimum number of bags we need to collect to fulfil our requirement. As we see Bag 1 covers Red , blue and Yellow balls . Bag 2 covers Red , Blue and Orange balls etc.

So in this case we collect Bag 1 and Bag 3 which in union gives $\{\text{Red, Blue, Yellow}\} \cup \{\text{Green, Orange}\} = \{\text{Red, Blue, Yellow, Green, Orange}\} == \text{Required balls}$. We can Collect Bag 1 , 2, and 5 to fulfil over need which is also a coverage set but not minimum.

- 4) Frequent Set: Taking more frequent symptoms is frequent mining. Here Bag 1 and Bag 2 are having more frequency of different balls. Our main idea is to show a set of symptoms which are Frequently covering the required disease set. By the above statement, we take Bag 1 and Bag2 (bag2 covers a new ball apart from bag 1) and Bag 3. Thus union of these:

$\{R,B,Y\} \cup \{R,B, O\} \cup \{G, O\} = \{ R,B, Y, G, O \} == \text{Required ball set.}$

- 5) Utility : We can get a doubt where 1 and 5 bags are covering the same set of balls and whom to select. Thus we are going to add an additional feature called utility which gives the bag preference . For eg bag 1 has 0.95 and Bag 5 has 0.9 , thus we select bag 1.
- 6) Unique symptom : for every disease there may or may not be a symptom which is unique to that disease only ie.. distinguishing characteristic symptoms of the particular disease. For example Jaundice has Change in skin color as a unique symptom.
- 7) Traversal : as we see in **Fig1** all symptoms can be placed in a hierarchical manner where a L1 has L2 symptoms as children and L2 may or may not have a set of L3 children. Children less nodes are terminal nodes. We traverse the tree top to bottom and back and prune the disease set at each step until we are left with only one disease where we can advise the farmer about the disease and its measures.

Algorithm using example:

Before that lets create the disease set for symptoms

Let the diseases list = { 101,102,103,104,105,106,107,108}

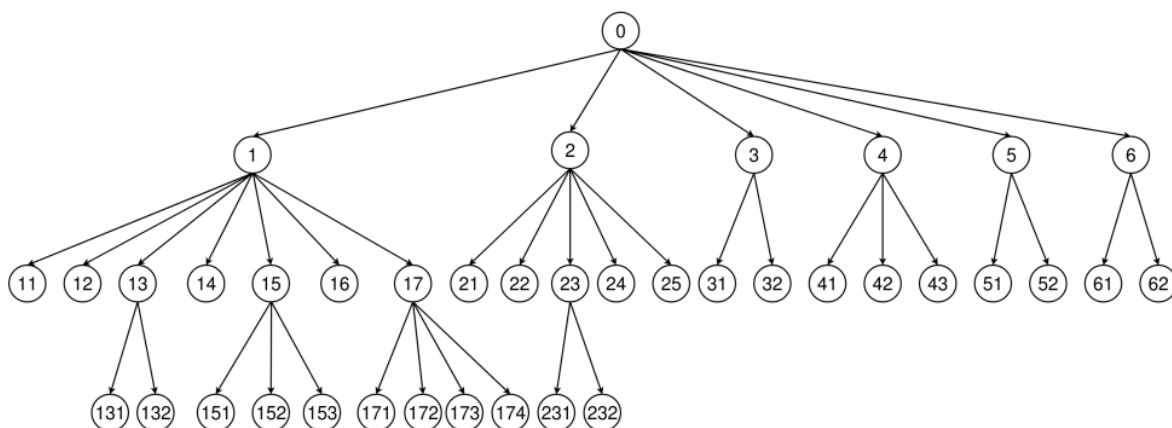


Figure 4.11: Illustrative example symptom-symptom relations (hierarchy)

Symptoms	Diseases.
1	102,103,104,105,107,108
11	108
12	107
13	102, 103, 107, 108
14	103
15	102, 105, 108
16	105, 108
17	102, 104, 105, 108
131	108
132	102, 103, 107

Let's assume the farmer selected 0 (cotton) crops. Now the system shows 1,2,3,4,5,6 L1 symptoms. Pruned Disease set is Disease set till last level \cap Disease set of selected symptom.

Let farmers select symptom number 1 from L1 symptoms shown. So Required disease is set to cover(RDS) = {102,103,104,105,107,108}. Our aim is to find a set of children symptoms which are frequent and cover the RDS. Then, as 1 has 11 to 17 as children. 13 is selected first which makes the Covered disease set(CDS) = DS(13) = {102, 103, 107, 108}. Next we select 17 as it is as frequent as 13 and covers an extra disease than what 13 is covering .Thus(CDS) = DS(13) \cup DS(17) = { 102, 103,104, 107,105, 108} =RDS.

Now as 13, 17 are shown let farmers select 13 which shows 131,132 and if 131 is selected we show disease 108.

Selected Symptom	Showed Symptoms	Pruned Disease Set
0 (cotton crop)	1,2,3,4,5,6 All L1 symptoms	101,102,13,104,105,106,107,108 (whole disease set of cotton)
1 (assumed L1)	13,17	Pds of last level \cap disease set if 1 (L1) symptom $\{101,102,13,104,105,106,107,108\} \cap \{102,103,104,105,107,108\}$ $=\{102,103,104,105,107,108\}$
13 (assume farmer pressed 13 of previous displayed 13 and 17)	131, 132	Pds till last level \cap Disease set(13) = $\{102,103,104,105,107,108\} \cap \{102, 103, 107, 108\}$ $= \{102, 103, 107, 108\}$
131 (assume farmer pressed 131)	Terminal	Pds till last level \cap Disease set(131) = $\{102, 103, 107, 108\} \cap \{108\} =$ $\{108\}$ As we reach the one disease at least we show the disease and show the advice.

132 is selected assume	<p>Terminal Being terminal we didn't prune to single disease so we go upwards to parents of L3</p> <p>So we show siblings of 13 which cover Pds . Thus we show 12, 14, 17</p>	$\text{Pds till last level} \cap \text{Disease set}(132) = \{102, 103, 107, 108\} \cap \{102, 103, 107\} = \{102, 103, 107\}$
Assume farmer pressed 12	As we ended up with one disease ie.. 107 we show this disease and its advise	$\text{Pds till last level} \cap \text{Disease set}(12) = \{102, 103, 107\} \cap \{107\} = \{107\}$

Assume farmer pressed 17	As we ended up with one disease ie.. 102 we show this disease and its advise	$\text{Pds till last level} \cap \text{Disease set}(17) = \{102, 103, 107\} \cap \{102, 104, 105, 108\} = \{102\}$
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As we see above we traverse till the last level and go to parents siblings and parents siblings and update prune disease set at each level and display the symptoms which cover the PDS of each level.

Finally some constraints in the algorithm

- 1) Whenever a farmer clicks L2 symptoms show directly all L3 symptoms of that given L2 without checking frequent coverage patterns.

- 2) At each level we check the pruned disease set and at a point where the size of the pruned disease set is ≤ 5 we show all unique symptoms of the corresponding disease in PDS.
- 3) Even if we end up with a PDS size 1 in first or second level which are having children, we still ask the children for confirmation.

Future plans include

- 4) Utility is yet to be added to selectively weigh a symptom when they cover the same number of diseases. Even in showing unique symptoms where there are more than one unique symptom for a disease, we need utility to selectively select one unique symptom.
- 5) While showing symptoms in the screen, if the coverage algorithm gave less than 5 symptoms to show, we show remaining symptoms to fill the screen(Yet to be added) .
- 6) Future plans include multiple disease identification and selection of multiple symptoms at a time in a page.
- 7) Addition of image to L3 level symptoms and for some L2 symptoms.