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Temperament and Mood Detection Using Case-Based Reasoning

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***Abstract*—** Case-Based Reasoning (CBR) is a branch of AI that is employed to solving problems which emphasizes the use of previous solutions in solving similar new problems. This work presents TAMDS, a Temperament and Mood Detection system which employs Case-Based Reasoning technique. The proposed system is adapted to the field of psychology to help psychologists solve part of the problems in their complex domain. We have designed TAMDS to detect temperament and moods of individuals. A major aim of our system is to help individuals who are out of reach of a professional psychologist to manage their personality and moods because as humans, moods affect our perceptions, personal health, the way we view the world around us and the way we react to it.

***Index Terms*—** CBR, Temperament; Mood, TAMDS, Artificial Intelligence

I. Introduction

Case Based Reasoning (CBR) is a paradigm in Artificial Intelligence (AI) that solves a problem by recalling a previous situation and solving the problem using previous cases [1]. The ultimate expression of artificial intelligence is to develop a system that mimics human reasoning approximately and can implement the general mechanisms underlying human intelligence. In other word, it involves developing a computer program that generates solution(s) to new problems based on first principles of logic. First principles are a logical discourse on topic matter that leads to a solution of the problem given in terms of knowledge human can understand. Rule based systems happens to be the earlier accepted AI techniques, these has however been found sort of limited due to the knowledge acquisition bottleneck and the time and cost involved to create a large rule base, verify and validate them, and keep them up to date. CBR is an emerging alternative in this regard.

Cases in CBR refer to problem situations or occurrences [2]. A previously experienced situation, which has been captured and learned in such way that it can be reused in the solving of future problems, is referred to as a past case, previous case, stored case, or retained case.

Cased Based Reasoning applies the same method human use in solving problems. A major distinction between CBR and other AI techniques unlike other techniques which relies on general knowledge of a problem domain, or making associations along generalized relationships between problem descriptors and conclusions, it is on its own able to utilize the specific knowledge of previously experienced, concrete problem situations (cases). In solving a new problem, similar past cases are searched for and used. Also, it presents an incremental approach to learning as new experiences from a present problem are kept for future use each time a problem is solved. It has been observed that humans solve problems by recalling a previously existed problem and how it was solved, apply it in relation to the existing problem and when successfully solved, the results are noted for future references. Thus, CBR relies on the use of memory in solving problems. For example, an auto mechanic who fixes an engine by recalling another car that exhibited similar fault signs is using case-based reasoning. A lawyer who advocates a particular outcome in a trial based on legal precedents or a judge who creates case-law is using case-based reasoning. Also, a doctor who after examining a patient refers to how another patient was earlier treated just because they exhibit similar symptoms and prescribes the same diagnosis and treatment is employing CBR. CBR institutionalize these forms of decisions and adaptation. It solves a new problem by recalling and considering previous cases, comparing it with the

present cases, learning from the case, solving the problem and saving the solution. One can as well conclude that Expert systems or Knowledge Based systems are subset of Case Based Reasoning [2]. Often times, in using CBR to solve a problem, there is usually no exact match for the current problem to use as a solution model, so it selects from the list of previous (available) solutions.

Formally, CBR system can be described in a cycle. This cycle comprises of four activities (the four-REs) [7] which can be separated into phases as detailed below. The cycle is also presented in Fig 1.

Retrieval phase: This is an important stage where a measure of how a present case is similar to past cases is done. A most similar case to the present case is then retrieved from the case base using some similarity metrics e.g. K-nearest neighbors has been mostly used by past systems and is also the adopted metrics in our work.

Reuse phase: This stage allows reusing and adapting the suggested solution (retrieved most similar case) to the target problem.

Revise phase: Here, a solution is revised or adapted to better fit the new problem if necessary. The adapted solution may be presented to the user for validation / confirmation.

Retain phase: this stage retains the solution and adds it to the case base once such solution has been validated. This allows the systemto learn from its experiences.

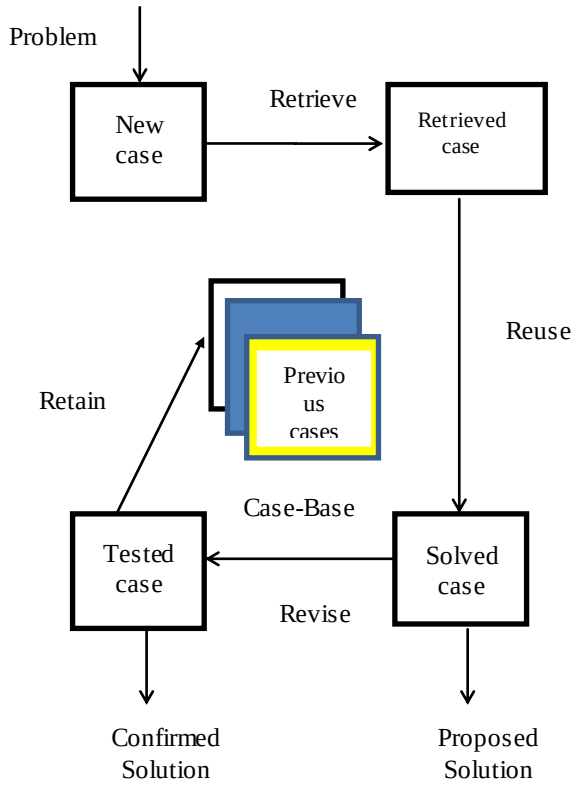

Fig. 1: Schematic representation of Case-Based Reasoning [1]

This paper presents TAMDS, a temperament and mood detection system developed to aid people in knowing their temperaments type and assessing their moods at any point in time. In the course of our work, some salient issue have been raised and addressed which leads to the development of TAMDS. For instance, our research aims at addressing some of these issues:

- When we talk of assessing person's mood and temperament, what methods/ techniques can be used for diagnosing such in a non-expert environment i.e. at home and in working places and are acceptable by the experts? This question addresses the need of a diagnostic system that not only supports in assisting the expert psychologist but also could be possibly used by users in their daily life. We reviewed different temperament types and mood swings.
- What is needed for enabling autonomous system able to identify individual's mood and temperament type? This looks simple on the surface but becomes much complex as humans exhibit traits of different temperament types. For this, CBR is researched in our work.
- How can we classify individual's temperament types when there are no clear guidelines to do so and the domain knowledge is weak? Works on temperament has only been well suited to psychologists because of its imprecision and ambiguity resulting from wide human behavioral diversities.
- How do we extract essential features from a person's feeling to be classified as a case, can these be well indexed and easily retrieved? This has also been well dealt with in our work and led to the design of an autonomous systemtagged TAMDS.

TAMDS acts intelligently by giving proper psychological advice and prescribing needed therapy to its users based on their state of mind and temperament types. Toeing the path of a reproducible research, we consulted and elicited personality cases (facts) from some human experts on some behaviors, actions and sets of traits that characterize each types of temperament and swings of moods for different temperament types based on their past interaction with clients, these interactions were encoded as our cases, the cases are used by TAMDS to draw inference and accurately classify the temperament type of an individual and of course, the current state of mind (moods) of such individual that conversed with TAMDS. This we believe is important and significant as knowing one's mood and getting psychological advice can go a long way in helping individuals relate and co-exist properly with people around them. An importance of TAMDS is that it affords its users a discovery of their temperament and complete state of minds as well as giving intelligent professional advice just the way an expert psychologist (counselor) will behave even if they don't have access to such experts or

cannot afford the cost of getting such professional advice.

The remaining part of the paper is arranged as follows; in the next section, we present a review of literatures explored and the related works, this is followed by the section presenting the proposed system. Next is the section on results and discussions. We give the summary of our work in the conclusion section.

II. Case Based Reasoning

Case-based Reasoning is the part of artificial intelligence that uses the retrieval and adaptation of old cases in solving new problems. It works as a set of four RE's. Case- based reasoning was established in the early '80s and has grown over the years. One of the pioneer works on CBR was done by Schanks in [4] [5]. In reference [1], a review of works on CBR was done. In their paper, they explained the foundational issues in its psychological plausibility. They opined that studies have shown evidences that previously experienced situations can form basis for solving similar new problems. Kolodner developed a system named CYRUS at Yale University [3]. The system utilized the Memory Organization Package (MOP) theory of solving problems as well as adapted Schank's dynamic Memory Model. Knowledge representation, case indexing and retrieval and adaptation of previous solutions to new problems were considered among the major problems of CBR. In the work of Massie [8], it was argued that classification boundaries represent important regions of the problem space. These classification boundaries are used to identify locations where new cases should be acquired. They introduced two complexity guided algorithms (COMPLEXITY and COMPLEXITY+) which use a local complexity measure and boundary identification techniques to actively discover cases close to boundaries. The ability of these algorithms to discover new cases that significantly improve the accuracy of case bases was demonstrated on five public domain classification datasets. In general, a significant improvement in test accuracy was observed with these new techniques compared to the random and competence-guided algorithms used as benchmarks. Pantic in his work [9] introduced a case-based reasoning system capable of classifying facial expressions (given in terms of facial muscle actions) into the emotion categories learned from the user. The utilized case base is a dynamic, incrementally self-organizing event-content-addressable memory that allows fact retrieval and evaluation of encountered events based upon the user preferences and the generalizations formed from prior input. Two versions of a prototype system were presented: one aims at recognition of six "universal" emotions and the other aims at recognition of affective states learned from the user. Validation studies suggest that in 100%, respectively in 97% of the test cases, interpretations produced by the system are consistent with those of the two users who trained the two versions of the prototype system. In [10], Burke et al. proposed a multiple-retrieval approach that partitions a large problem into small solvable sub-problems by recursively inputting the unsolved part of the graph into the decision tree for retrieval. The adaptation combines the retrieved partial solutions of all the partitioned sub-problems and employs a graph heuristic method to construct the whole solution for the new case. They presented a methodology which is not dependent upon problem specific information and which, as such, represents an approach which underpins the goal of building more general timetabling systems. The work in [18] outlined popular case-based reasoning combinations. They specifically discussed several combinations of case-based reasoning with rule-based reasoning, soft computing and ontologies. A novel similarity measure to design a Decision Support System for products selection based on CBR was presented in [19], Nearest Neighbour algorithm was used for matching case in the case base. They claimed that their system helped users to find the optimal product according to their preferences. The authors of [13] presented a report on CBR adaptation to medical field. They discussed the appropriateness of CBR for medical knowledge-based systems, the possible problems, limitations and ways to handle the problems. The work in [20] contains a survey of approaches integrating rule-based reasoning with case-based reasoning. The authors described a categorization scheme for the integrated formalisms with representative approaches of each category. The authors also reviewed CBR systems that adopt rule based reasoning, soft computing and ontologies in [21], giving illustrations of the basic types of such combinations and future directions. Most efficient AI systems have often operated as a form of rule based systems. Questioning our choice of adopting CBR for temperament and mood detection is a matter of weighing up the merits and demerits of both. Rule based system and CBRs have been compared in terms of their benefits to different domains [22], it has been found that CBR clearly excel in domains where problems have many exceptions to rules, it is pertinent to know that humans exhibits traits of several temperaments which makes hardcoding rules to classify actual temperament and mood very difficult, thus our choice of CBR.

While to the best of our knowledge, no work has adapted CBR to temperament and mood management, still others have worked on slightly related areas. A most related work to ours is [11], where CBR was adapted to stress management. They developed a hybrid case-based reasoning system for stress diagnosis capable of coping with both numerical signals and textual data. Fuzzy similarity matching metric was employed in sensor measurements while an enhanced cosine matching function was used for evaluation of similarity on the textual cases. The authors in [12] developed a decision making support system for clinical decision for the diagnosis and the therapy of Chronic

Obstructive Pulmonary Disease (COPD), a tobacco causing disease. They used an expert system using forward chaining for the adaptation phase. They claimed that expert system models well the adaptation task and gives satisfactory answers to the user. Work on similarity metric was done in [15] and [14] employing fuzzy logic for accurate case retrieval process.

Below, we discuss temperaments, moods and varying classification of temperaments and how they distinguish different personalities.

2.1 Temperament

Temperaments are part of an individual's personality. It can be referred to as a person's or animal's nature as it permanently affects their behavior. They are innate characteristics that are never learnt. Behavior is considered as part of an animal's phenotype and is loosely defined as everything an animal does and how it does it, provided it can be observed and measured. The measurement or evaluation of an individual's behavior is basically considered under temperamental traits. Although temperament is biologically based, however, this does not necessarily mean that temperament is inherited. The four temperament type is a proto-psychological interpretation of the ancient medical concept of humorism and suggests that four bodily fluids affect human personality traits and behaviors. The temperaments are:

Sanguine – fun-loving and extroverted

Choleric – ambitious and opinionated

Melancholic – introspective and seclusive

Phlegmatic - deliberative and quiet

2.1.1 Sanguine

The sanguine are said to be with abundance of blood [16]. The sanguine person does not penetrate the depth, the essence of things; he does not embrace the whole. He loves light work which attracts attention, where there is no need of deep thought, or great effort. A sanguine person is fun-loving and loves activities that involve a lot of energy. A sanguine person is unstable and encounters frequent alterations of mood say from happy to sad and vice versa. He is fashionable and is happy when praised.

The example case scenario below typifies a person with sanguine personality trait;

- Ngozi (age 24) is self-composed, seldom shows signs of embarrassment, perhaps forward or bold. She is always eager to express herself either before a group or not; she simply likes to be heard. She prefers group activities either as work or play but not easily satisfied with individual projects. She is not insistent upon acceptance of her ideas or plans; agrees readily with others' wishes. She is good in details and prefers activities requiring pep and energy. She has a little problem of being impulsive and usually her decisions are often wrong.
- Ejiro (age 28) is a fun-loving, activity-oriented working class lady. She prefers a lot of group activities as well as makes friends easily. She is keenly alive to environment, physical and social. She is quite curious. She tends to take success for granted but lacks initiative. She is hearty and cordial, even to strangers and forms acquaintanceship easily. She is not given to worry and anxiety. She turns from one activity to another in rapid succession with little perseverance. She is fashionable. She is frank, talk-able and sociable. She readily expresses emotions and does not stand on ceremony

Just as in expert categorization, a person is considered sanguine if he/she exhibits any of these features e.g. If an individual is self-composed and seldom shows signs of embarrassment; sociable or likes going out and meeting people; forward or bold, always eager to express herself either before a group or not; prefers group activities either as work or play but not easily satisfied with individual projects; not insistent upon acceptance of ideas or plans; agrees readily with others' wishes, good in details and prefers activities requiring pep and energy; impulsive and usually her decisions are often questionable or takes rushed decisions; Fun-loving, activity-oriented and makes friends easily; keenly alive to environment, physical and social; not worried or anxious and likes to inquire about things; curious and tends to take success for granted but lacks initiative; hearty and cordial, even to strangers and forms acquaintanceship easily; not given to worry and anxiety; turns from one activity to another in rapid succession with little perseverance; fashionable, talk-able and sociable; Frank and readily expresses emotions and does not stand on ceremony; Makes wide and broad range of friendship and not selective; makes adjustments easily, welcome changes and make the best appearance possible; experiences frequent fluctuations of mood, different alterations of elation and depression; quickly aroused and vehemently excited by influences; loves shopping and has large appetite for food; happy when praised or susceptible to flattery

2.1.2 Choleric

A choleric person is ambitious. He prefers leading to being led and takes success for granted. He is self-confident and self-reliant or usually sure will succeed with or without help. A choleric person usually insists upon his ideas being accepted. He exhibits decisive moves with pronounced or excessive energy. He plans events or actions before they are carried out but hardly give in to emotions or express emotions except anger, that is, he thinks emotions are for weak people. A choleric person can readily make the best possible appearance even if it means the use of hypocrisy, deceit or disguise - attaches importance to appearance and

looks. The given cases below typify a choleric character trait;

- Mrs Balogun (age 40), is the manager of a company. She hates people who appear weak and feeble. She attributed all her success to hard-work though she takes success for granted. She makes the best of appearance Is insistent upon the acceptance of his ideas or plans; argumentative and persuasive. She is impetuous and impulsive but prefers to lead. She reacts strongly to praise or blame and she is very sensitive. She is quick and decisive and often plunges to situations where fore-thought would have deterred her. She has a marked tendency to persevere. Her little fault is that she can be very stubborn about anything she sets her mind on.
- Musa (age 30), an engineer likes to keep to time. A core achiever, he hates for anything to stand in his way of purpose. He is a go-getter. He is self-composed. He seldom shows embarrassment. He is usually forward and bold and this can be mistaken for pride. Moreover, he insists on his opinion being accepted because he views other people's opinion as not being strong. He is eager to express himself before a group if he has some purpose in view.

An individual is choleric if he shows majority of these characters;

- is ambitious, forward, bold and self-composed; Often shows embarrassment or does not condone embarrassment of any kind; always eager to speak up new ideas to a group and insists on ideas being accepted; persuasive or argumentative; impulsive or usually venture into situations where forethoughts would have deterred such actions; prefers leading to being lead; takes success for granted; self-confident and self-reliant or usually sure will succeed with or without help; exhibits decisive moves, pronounced or excessive energy; lies to plan events or actions before they are carried out; hardly give in to emotions or express emotions except anger; thinks emotions are for weak people; can readily make the best possible appearance even if it means the use of hypocrisy, deceit or disguise; attaches importance to appearance and looks; hardly satisfied with the ordinary or thinks things should be done with utmost seriousness; aspires for the highest position there is or usually strong-willed; considers yourself as something extraordinary and as one to be called to do great or extraordinary things; usually stubborn and opinionated; feels always right and never willing to give in; feels capable and view other people as weak or not capable enough

2.1.3 Melancholic

A melancholic person is self-conscious, easily embarrassed, timid and bashful. He can be said to be shy and usually introverted. He avoids talking before a group and when obliged to, finds it difficult. He prefers to work and play alone except in the company of close friends. He is good in details and usually careful therefore he worries over possible misfortune and cross bridges before coming to them. He keeps things to himself; shut in and not inclined to speak unless spoken to. He is slow in movement; deliberative or perhaps indecisive. He is usually modest and unassuming, feebly excited by anything and has weak reactions to situations but have lasting impressions which is usually difficult to eradicate. An example of a melancholic character traits personality is given below;

- Amaka (age 24) is a very shy girl. She has lost many opportunities as a result of her withdrawal from groups or people. She is said to be extremely reserved. She is quite very thoughtful; she searches for the meaning and correlation of things. She very sensitive and is easily hurt; this makes her moody and makes people to stay away from her. Her problem is that she complains not having friends but she is not even moved to making some. She does not form acquaintances readily, prefers narrow range of friends and tends to exclude others. Amaka is a worrier; she worries over possible misfortune and crosses bridges before coming to them. One big problem she has is indecisiveness.
- Niyi (age 23), a fresh graduate, is self-conscious, easily embarrassed, timid and bashful. He avoids talking before a group; when obliged to he finds it difficult. He refers to work and play alone. He is good in details but very careful. He is deliberative, slow in making decisions and perhaps overcautious even in minor matters. He is lacking in self-confidence and initiative but is compliant and yielding. He tends to detachment from environment, usually reserved and distant except to intimate friends. He tends to depression either frequently moody or gloomy.

An individual is classified to be melancholic if such a person is

- self-conscious, easily embarrassed, timid and bashful; always shy and usually introverted; avoids talking before a group and when obliged to, find it difficult; prefers to work and play alone; good in details and usually careful; deliberative, slow in making decisions and perhaps overcautious even in minor matters; lacking in self-confidence and initiative; tend to detach from environment; reserved and distant except to intimate friends; open to depression; frequently moody or gloomy; very sensitive and easily hurt; not form acquaintances readily; prefers narrow range of friends and tends to exclude others; worries over possible misfortune and cross bridges before coming to them; keep things to yourself; seclusive; shut in and not inclined to speak unless spoken to; slow in movement; deliberative or perhaps indecisive; usually modest and unassuming; feebly excited by anything; has weak reactions to situations but have lasting impressions which is usually difficult

to eradicate; often searches for causes and correlation of thing; is extremely soft-hearted; usually inclined to introspection or is reflective about all things and quite religious; takes a long time to make up your mind or is irresolute; not opinionated or stubbornly insists on pinions being accepted; lacks courage to take certain actions and often require motivation; often works carefully and reliably without considering time constraints on the job; not seek honour and recognition and perhaps hates to be called in public to be praised; afraid of being put to shame which consequently makes you to retire; finds it hard to apologize as a result of the embarrassment it will cause you; vehemently exasperated or provoked because of injustice and disorder; finds it hard to forgive offences and thinks about them over and over; sees everything from the dark side or usually suspicious and rarely trusts people; holds grudges over offences much longer.

2.1.4 Phlegmatic

The phlegmatic person is usually deliberative or prefers to reason things out. He is slow in making decisions and perhaps overcautious in minor matters. His major characteristic is that he seems indifferent to external affairs and acts as if they don't exist. The phlegmatic has a marked tendency to persevere and often exhibits constancy of mood. His weakness includes little inclination to work, but prefers repose and leisure and his views about everything as proceeding and developing slowly. A case scenario of a phlegmatic character is given below;

- Bola (age 25) is deliberative and slow in making decisions and perhaps overcautious in minor matters. She is indifferent to external affairs. She is reserved and distant. She is slow in movement but makes progress with that slow but steady pace. She has a marked tendency to persevere but is not moved by things around her. She exhibits a constancy of mood. She is not easily exasperated either by offenses, or by failures or sufferings. She remains composed, thoughtful, deliberate, and has a cold, sober, and practical judgment. She has no intense passions and does not demand much of life.

A person is classified to be phlegmatic if such a person is usually deliberative or prefers to reason things out; slow in making decisions and perhaps overcautious in minor matters; often seems indifferent to external affairs and acts as if it doesn't; reserved and distant or slow in movement or in actions; have a marked tendency to persevere; often exhibits constancy of mood; not usually touched by impressions or moved; event or situations do not create lasting impressions; has little interests in things that go on around; has little inclination to work, but prefers repose and leisure; views everything as proceeding and developing slowly; not easily exasperated by offences, failures or sufferings; exhibits cold, sober, and practical judgment; Not usually passionate about anything in life; very much inclined to ease, to eating and drinking; finds yourself neglecting duties; not usually ambitious, and does not aspire to lofty things, not even in your piety

2.2 MOODS

Mood is defined as the prevailing psychological state (habitual or relatively temporary). It is further defined as a feeling, state or prolonged emotion that influences the whole of one's psychic life. It can relate to passion or feeling, humor; as a melancholy mood or a suppliant mood. Mood can and does affect perceived health, personal confidence, one's perception of the world around us and our actions based on those perceptions. Moods can and do change often although mood swings of a sharp nature may be a symptom of underlying disease. Moods may signify happiness, anger, tension, or anxiety. Chronic periods of any mood state may be an indicator of a disorder as well. Moods are subjective state of a person's mind. It elicits an individual's subjective emotional state. Affect in psychology is the objective appearance of mood. Moods can be temporary but sometimes lasting more than expected. In the cases where certain mood conditions persist, as a result of some events or the other, such a person is advised to seek medical help. An example of a person on a prolong state of depression which has perpetually negate the person's mood is given below;

- Damola has been referred to a counselor for psychotherapy following a suicide attempt. When interviewed, he is very teary. He speaks slowly and looks down at the ground as he speaks. He reports difficulty in falling asleep and staying asleep for the past month. Damola states that he hasn't had much of an appetite and has lost 15 pounds. He reports that things he used to like just don't seem enjoyable anymore, and he thinks that life is not worth living. Damola doesn't expect things to improve in the future, which is why he tried to kill himself.

In this paper, Case-Based Reasoning has been applied to temperament and mood detection as a fresh approach to the domain of psychology. Even though some of the earlier works have adapted CBR techniques to varying problems, for instance, some papers have addressed issues on medical diagnosis using CBR in [11] [12] and [13], we consider our work novel as to the best of our knowledge, this work can be considered as the first to adopt CBR techniques in the area of personality traits detection and management. The work gives a report of our continuous work in developing a system that helps individuals find out about several personality traits and their weaknesses, as well as several alteration of mood so as to manage these feelings to avoid extreme situation.

III. Temperament and Mood Detection with CBR

In this section, we present a Temperament and Mood Detection System (TAMDS), developed in JAVA which employs Case-Based Reasoning technique. Oftentimes, there have been some questions raised on functionality of CBR. These questions mostly are

- ✓ What is structure of the cases?
- ✓ What are selection strategies for finding similar cases?
- ✓ How is the case being retrieved?
- ✓ How is the selected case being revised?
- ✓ How is the suggested case being stored in case base?
- ✓ How is suggested case being indexed for faster access in the future?

This section addresses these issues appropriately. Furthermore, we discuss the functional units of TAMDS and the methodology behind its reasoning and deductions; we give a breakdown of the rules adopted, the cases used and the way TAMDS operates.

3.1 Knowledge Acquisition

In our work, we acquired knowledge through different sources. CBR on its form is rather based on cases and cases are almost always similar, therefore, solutions can be reused. CBR, on the other hand, does not compulsorily require core background knowledge elicitation from the domain expert i.e. CBR is not rule-based, thereby eradicating the problems encountered in developing some AI systems such as Expert Systems. However, we acquired cases from experts in form of their past interactions with clients and the classifications of temperaments given to those clients, this was done in order to get cases as close to the real world as possible. Also, some information was derived from interviews as well as several temperamental and psychological books. These are classified under these categories:

- The characteristics of the four basic temperaments
- The possibilities of an individual possessing more than one temperament type
- Mood disorders and symptoms
- The relationship between moods and temperament

The facts elicited as knowledge above are listed as a form of features encoded as the cases covering a broad personality trait which the system can reuse for learning and accurate prediction of users traits and moods based on some particular similarity ratio.

3.2 Cases

A case in CBR is a situation – the basis of what was experienced. The authors in [2] defined it as a contextualized piece of knowledge representing an experience that teaches a lesson fundamental to achieving the goals of a reasoner. They further gave a listing of the three major parts to any case, these are presented as below:

- Problem description: the state of the real world at the time the case occurred and, if appropriate, what problem needed to be solved at that time.
- Solution: the stated or derived solution to the problem specified in the description, or the reaction to its situation.
- Outcome: the resulting state of the world when the solution was decided.

Cases may be stored as separate knowledge units, or split into subunits and distributed within the knowledge structure. Indexing can be done using a prefixed or open vocabulary, and within a flat or hierarchical index structure. Depending on the implementation, the solution from a previous case may be directly applied to the present problem, or modified according to differences between the two cases, i.e. the present case and the past experience. The matching of cases, and selection of solution could be based on a general knowledge of the domain or purely through a syntactic similarity of cases.

The representations of the problem description, solution and outcome components of a case make it possible to reuse, revise and retain cases. Since cases are unique chunks of information, contradicting cases do not occur.

For example for someone having a major depression disorder, it will be recorded of that individual to have had seasons of cases such as;

1. Thoughts of suicide
2. Several moments of sadness and depressed mood
3. Months of feeling of hopelessness
4. Seclusion from social gatherings or fun outings, etc.

3.3 Case Representation

CBR systems relies heavily their case memory, this is obvious since solutions to new problems are derived from past solutions. The representation problem in CBR has to do with deciding what to store in a case, finding an appropriate structure for describing case contents, and deciding how the case memory should be organized and indexed for effective retrieval and reuse [1]. Also to be considered is the integration of the case memory structure into a model of general domain knowledge such that such knowledge is well incorporated. While representing a case, it could be considered to be a situation where a problem is completely or partially solved. A case therefore represents an episodic combination of problems and solutions, i.e. a pair

consisting of Problems (P) in the P domain and Solutions (S) in the S domain which may include an explanation E, and this can be represented as

(P→S, E)

Where P is the problem and S is the solution and E is the explanation of the solution. Our case representation is patterned after Schank's Dynamic Memory Model (DMM)[4]. Here, the case memory is a hierarchical structure of episodic memory organization packets' (E-MOPs [3]). Specific cases which share similar attributes are placed under the same class referred to as a generalized episode (GE) which contains 3 items; Norms, Cases and Indices, where Norms are features common to all cases indexed under a GE, Indices are features which discriminate between a GE's cases and an index points to a more specific GE or directly to a case. Also, an index is composed of two terms i.e. an indexname and an indexvalue. Readers can refer to [1], [2] and [3] for more explanation. It should however be noted that the main task of a GE is to provide a generalized indexing structure for matching and retrieval of cases. In the case-base of TAMDS, data structures hold and access these cases. However, these data structures are a flat list of pair-represented cases. The organization of cases in TAMDS is done in such a way that it is represented as a sequential array of related characteristic traits of feelings.

3.4 Knowledge Representation

This section presents a knowledge representation approach employed in TAMDS using case-based reasoning. The domain knowledge is represented in a more realistic way in order to allow each individual to get the accurate or supposedly correct solution to his/her problems. The process of knowledge representation in our work follows semantic model. Semantic analysis is a method for eliciting and representing knowledge about an area of interest. In this model, cases are referred as exemplars. The knowledge is represented in terms of categories, cases and index pointers, all of which form a semantic network. In the model, each case is associated with a category. An index may point to a case or a category.

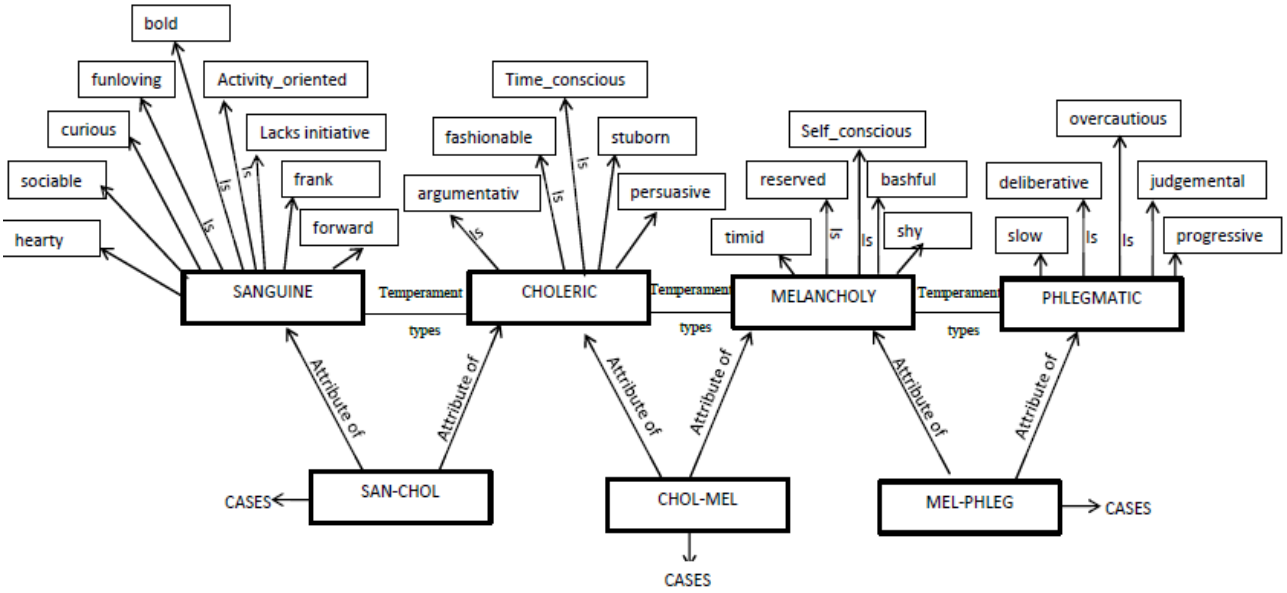

Fig. 2: Semantic Network Representation of temperaments showing the correlations between the temperament types

3.5 Case Indexing

Case indexing can be referred to as the systematic arrangement of cases in the database so as to enable accurate and applicable case retrieval. Indexing assigns indices to cases to facilitate their retrieval. In indexing a case, the features of that case tends to be predictive; this will enable the system to retrieve the right case at the right time considering the input. Cases are indexed by their attributes and are retrieved by matching these attributes to the new input problems. For each temperament type or mood state, there are different attributes. Matching cases in TAMDS starts with the first input attribute, the system scans for keywords in the input problem and retrieves cases based on these keywords. In this way, solutions are provided based on matched cases. In our work, we have employed words, descriptions, and classifications to index cases so as to enable accurate prediction of solutions.

3.6 Case Retrieval

Retrieval is an important aspect of CBR. Problems are encoded as queries to the system which uses retrieval mechanism to match input against cases in the database. In a CBR system, sometimes a problem may not get an exact solution, in which case, a derived solution can be employed by the use of the system's adaptation model. The proposed system adopts a

syntactic and semantic similarity assessment. First, features are identified from the input descriptors then an initial scan is done on the case base for similarity matching, finally, a best match is chosen.

TAMDS performs case retrieval as follows, first, a user enters a new problem case to the system in order to either check his temperament type or mood diagnosis and advice. The system activates a parser that scans the entered case and breaks it down into word groups, these word groupd are made up of keywords that really defines a temperament type as earlier given in the section under ltemperaments , non-keywords terms that forms parts of the sentences are disposed off temporarily. The selected keywords are grouped as features terms which provides a way of finding morphological variants of searched terms and can be used to match the cases in the database. The selected keywords are used to match all the features which describes earlier cases housed in the case base using a bi-directional search, to get the most relevant case from the list of cases, each hit keyword is ranked and associated with a weight computed as a function of its frequency of occurrence in the case base. Similarity matching plays an important role in Case-based reasoning systems. Different matching algorithm or measurements approaches can be applied to calculate the similarity between the feature values of a current case and an old case. In our system, to perform similarity measurement; we employed the Nearest Neighbor algorithm [1] [17]. This mechanism locates the case that is most similar to the input problem. The intuition can be described as below:

For input: a set of n points in d dimensions

$$K = (k_1\ k_2\ \ldots\ldots\ldots\ldots\ k_n)$$

Desired output

For each point k ϵ K, the nearest point to k

This is done using the formula (i) that follows

$$\text{Similarity } (C, S) = \sum_{f=1}^{n} W_f * \text{sim}(C_f, S_f) \quad \text{(i)}$$

Where C is a current case, S is a stored case in the case base, w is the normalized weight, n is the number of attributes or features in each case, f is the index for an individual attribute/feature and sim(C_f ,S_f) is the local similarity function. The usefulness of a case is estimated based on the presence or absence of certain features. These features specify which case is meant to be retrieved. In the representational approach, the cases are pre-structured and retrieved by traversing the index structure, e.g. memory organization packets (MOPS) [5]. Similarity is assessed based on the location of the case in the indexing structure; neighbors are assumed to be similar. The nearest-neighbor method gives every feature a weight and results in a weighted sum to measure the similarity between two cases.

3.7 Adaptation Process

In adaptation, retrieved cases are revised and adjusted to fit the new situation. Adaptation is considered one of the most difficult tasks in developing CBR systems, because it requires modeling domain knowledge.

There are three general kinds of adaptation [2]

- Parametric adaptation
- Structural adaptation
- Generative adaptation

This paper adopts the use of structural adaptation mechanism. This involves the repair of certain aspects in the solution to fit the new problem, for example applying certain rules or other manipulation to the solution. We have structured it in a way similar to the transformational analogy approach where analogy to the stored problem requires transforming the stored solution to fit the new problem. As a matter of fact, this same approach is adopted by the Nearest Neighbour (NN) technique and maybe combined with taking the inverse distance weighted mean for K Nearest Neigbours (KNN) when K>1.

In our model shown in figure 3, the arrows show the inter-relationship between components of the system. At the login, the user interacts with the system using the graphical user interface (GUI). Here the user is either an existing user or a new user. The interface opens and invokes the knowledge acquisition phase where a user is allowed to converse with the system and enters a new case based on his/her conversation with the system. The user selects whether it is temperament or mood swing his/she wants to evaluate. While the user converse with the system, the system picks the keywords and evaluates it with the cases in the database. The system finally evaluates these attributes and selects a most similar case from past cases in the database based on Nearest Neighbor metrics adopted. The system then checks the solution of the retrieved similar case and reuses the solution to inform the user of his/her temperament or mood and can then advise the user on such. In the case of mood inquisition, the system reveals the user's state of mind as well as tells the user whether the mood should be maintained, managed or an expert's help is further needed.

After the solutions have been proffered, the system checks the case against the cases in the database as to know whether a completely similar case existed or whether to save up the new case. Solutions are also saved up in the database. These solutions are called when a new user inputs a similar problem; otherwise a new solution is proffered. Therefore, the solutions are stored in the database for future access references. It functions to maintain the processes of retrieve, reuse, revise and retain of cases and user's information.

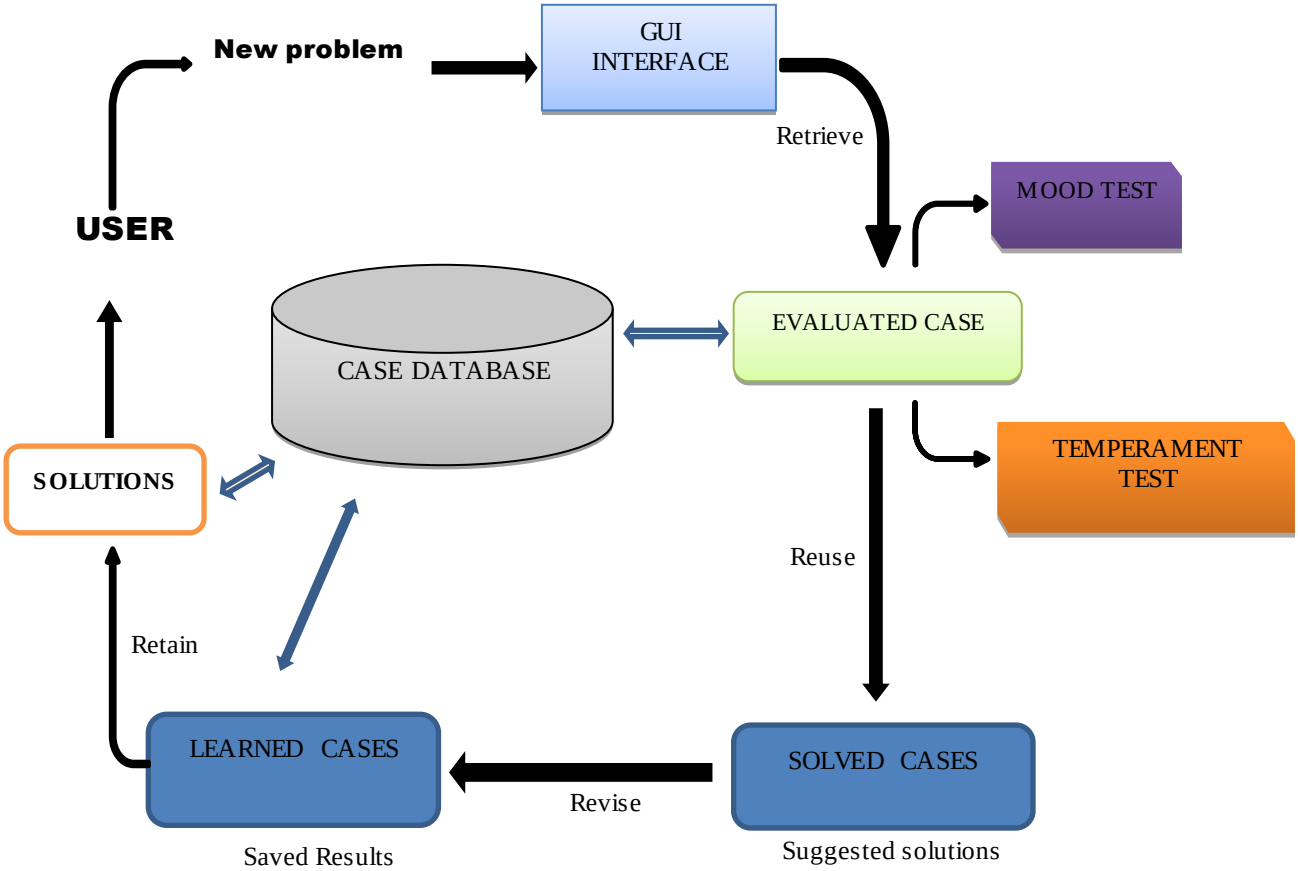

Fig. 3: Schematic representation of TAMDS

In developing TAMDS, we have followed the basic rules of CBR as a form of problem solving technique. These include:

Case RETRIEVAL: The purpose of case retrieval is to find a case in the case-base whose problem description is the most similar to the current input problem. The case retrieval process is typically divided into two sub-processes - a simple process which identifies the input problem's features and searches out a set of similar cases from the case-base, and a more elaborate process which selects the best case from the set of similar cases. To identify input problem features in the first sub-process involves developing a module to take the user's narrative problem as input or simply instantiating a predefined feature model. The former needs to 'understand' the problem within its context, filter out noisy or unimportant features and keep relevant ones. In the latter case, the reasoner is told which features are important by a knowledge engineer.

Case REUSE: a case reuse is done when a case retrieve suits the new problem. In such case its solution is adapted to solve the new problem.

Case REVISION: this is otherwise used if case reuse does not happen. In this case, the system has to adapt a particular case to an existing case. This adapted case is used to solve the new problem.

Case RETENTION: TAMDS performs a RETAIN operation when a solution has been validated. This solution is then saved to the database.

IV. Performance Evaluation and Discussion

Accurately classifying a person to be of any particular personality trait has often been difficult because there is no generally accepted and already algorithm or mathematical expression for performing such classifications. Because of this, most psychological therapy which aims at managing people's behavioral and mental state through moods and temperament control has often been done by an expert psychologist who acts as a professional counselor. As CBR dwells on reusing solutions of similar past problems in solving new problems, we presume it as an appropriate technique for this problem as actual case instances are available. With CBR techniques professional psychologist could soil refer to records of previous clients with similar behavioral traits and adapt it for another clients with similar psycho-history.

For the purpose of our work, information from 62 volunteered students of the department of computer science, Oduduwa University, Ile-Ife, Nigeria were used to form our dataset. Using a professional human questioning attributes, 20 students were debriefed with

the available question sets on their behavioral traits, giving a probe into their temperament type and mood swing as at that time. Relying on expert decision, the obtained behavioral traits were manually classified into different behavioral class, important students' response were broken down into several syntactic units each representing a deduced feature for indexing, each feature extracted was assigned a weight which depicts its importance in matching similar cases. These features, the whole response (i.e. reply to each question set) and the manually deduced solution were encoded and stored into the case base. The remaining 42 students were used as test set with each student serving as a user of TAMDS, the system conversed with them and automatically debriefed to get their behavioral traits to form a present case, present cases were compared with cases in the case base based on the NN matching algorithm, cases are ranked in the order f their similarity to the present case and the solution of the most similar (highest ranked) case retrieved. The system was successful as it was able to accurate classify the traits of test set students with an accuracy of 93.20% when compared with an expert's analysis of the same setoff test set students.

V. Conclusion

In this work, we have proposed TAMDS, a temperament and mood detection system we have developed. The system was developed to stand in gap for an expert psychologist in properly predicting the moods of an individual as well as given their temperament type. TAMDS does this by learning from past cases of individual moods' expression as well as personality traits. Of this, we have deduced some features that characterizes known temperament types from which the system can accurately classify the user's temperament based on the person's characters while also being able to deduce the person's mood and give good advice on how the person can best manage his/her temperament and the mood the person might be in at any point in time. we have employed the nearest neighbor classifier as the similarity metrics which measures the similarity of the present case (based on the user the system is currently attending to) with all the cases in the database before selecting and retrieving the closest case which the system now use in making its deductions. Away from other works, we have not addressed some technical issues involved in case retrieval and indexing such as employing fuzzy logic in feature classification for retrieval as well as adopting expert systems for the adaptation phase as done in some works, this we hope to address in our future works. Also, our work is solely limited to temperament and mood detection, any expert advice sought from and given by the system is limited to this scope

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