To

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Received documents purporting be to an application for a patent numbered "1431/MUM/2012" dated "10/05/2012 11:22:59" by "DR. ANUPAM SHUKLA" of "ABV-IITM, MORENA LINK ROAD, NATIONAL HIGHWAY, GWALIOR, 474010, INDIA" relating to "SYMPTOM WEIGHTED IDENTIFICATION METHODOLOGY (SWIM)" together with the "Complete Specification" and fee(s) of Rs. 1000 (One Thousand only)

Note:
1. In case of a Patent Application accompanied by a Provisional Specification, a Complete Specification should be filed within 12 months from the date of filing of the Provisional Specification, failing which the application will be deemed to be abandoned under Section 9(1) of the Patents Act, 1970.
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We Claim, that

1. Currently only heuristic methods are available, the proposed method identifies the species of snake and classifies severity in 4 categories using deterministic methods.

2. This technique takes into account 28 medically known parameters. It was identified that among these parameters some are either present or absent in a particular species envenomation. Like, In Russell’s viper, Blisters develop on limbs/trunk of the victim, which has not been found in any other species envenomation. Similarly, BT/CT rises in viperine envenomation but not in elapid envenomation. This technique uses identification of species by the appearance of these specific symptoms.

3. The output provides identification of the species and also provides the severity of envenomation. That may help in subsequent medical management. This is combination has not been observed in literature earlier.

4. In many areas of the world, there are many venomous species co-exist. The same method may be applicable when number of species is more than five. But, in that case the number of symptoms and nature of symptoms may be different.

5. This method is realizable on computing devices based on android operating system with simple mathematical operations and sufficient memory.

6. This method can also be realized in hardware with voltage source, switches and resistances.

7. This method was validated on a 34 cases of hospital records, and it was found that this method provided no error in establishing the envenoming species.
8. The response time takes less than 10 ms in yielding the result and the total time required for entering the input is less than 2 minutes.

9. This method is simple, does not violate any medical ethics, does not suggest any invasive procedure and does not obstruct the medical management.

10. This method may be applicable in some other applications, where a large number of effects of are seen due to a defined set of causes but there is discernible and visible difference in patterns manifested.
Figure 1: Normalization of Age

![Normalization of Age Graph](image-url)
Figure 2: Normalization of Delay

![Normalized Delay graph]

Normalized Delay

Normalized value

Delay in hours

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

0 1 2 3 4 5 6 7 8
Figure 3: Network Topology
SYMPTOM WEIGHTED IDENTIFICATION METHODOLOGY (SWIM)

BACKGROUND OF INNOVATION

Venom is a defense tool for many species, including snakes and scorpions. Human beings get affected by venom as a result of survival conflicts between species. Often, the venom yielding species are not identified by the victim or the witness, which results in improper medical management of the victim. However, it has been experienced that the symptoms developed in the victim are species specific. So, a method, SYMPTOM WEIGHTED IDENTIFICATION METHODOLOGY (SWIM), is being proposed which takes into account a number of symptoms developed and commonly observed by the medical staff, when the victim is brought to the healthcare centre. Using the heuristic knowledge available, a set of symptoms are chosen and added in a weighted fashion to suggest the venom interacting species. Also, a number of weighted symptoms may indicate the degree of severity of venom interaction. This method may be very useful for the healthcare professionals in identifying the venom interacting species.

a. VENOM AND VENOMOUS SPECIES

Venom is a mixture of proteins and peptides. Venom existed in the nature as one of the most early survival means. A number of species evolved venom and in the continuous quest for survival, ameliorated the venom constituents and venom delivery apparatus. The venomous species use venom to control, kill and digest their prey. Alternatively, it is used as a defense against an aggressive enemy. Once, the venom enters inside the victim’s body at subcutaneous level, its different constituents start working synergistically, which includes decomposition of cell membranes, cleavage formation in tissues, proteolysis, synaptic blockades, cardiac complications etc. Some components in the venom target some specific organs or systems for faster termination of the victim.
**Scorpions**: They belong to the phylum Arthropoda, order Scorpionida in the class Arachnida. Their venom delivery apparatus is a pincer located on the caudal tip. Their venom is primarily neurotoxic in nature, meant to immobilize small insects. Indian Red Scorpion or *Mesobuthus Tamulus* is known as the most lethal scorpion observed in India.

**Snakes**: They are the most familiar reptiles all over the world. Being poikilothermic, they prefer warm climates for inhabitation. Unlike most other animals they do not have any limbs. They have only to attack and grab the prey or defend themselves against an aggressor. The snake bites a human being in order to defend itself when approached too close. Snakes can be divided into three teeth categories, aglyphs, opistoglyphs and proteroglyphs. The aglyphs do not have venomous teeth and the opistoglyphs have posteriori located venom delivery teeth.

The proteroglyphs have their fangs located in the maxilla and connected to the modified salivary gland, which produce highly toxic venom. The venomous snakes have four families Viperidae, Elapidae, Colubridae and Hydrophidae. In the current context, this discussion is related to the former two families only. The venom of the Viperidae is largely hemotoxic and primarily causes local symptoms. While, the venom of Elapidae snakes is often neurotoxic and upon interaction, may cause neuropathy as well as cardiomyopathy.

The patients bitten by an elapid snake often reach in a state of emergency earlier than a bite case of a viper. However, as time passes the general condition of the victim deteriorates in all the venom interacted cases. The in-vivo venom quantity attacks the specific target systems and a number of complications may be triggered. The symptoms, rate of development of symptoms, clinical support and required medicinal attention varies with the species. So, identification of the aggressor venomous species and the degree of envenomation play important role in medical management.

**b. VENOM INTERACTIONS IN INDIA**
Majority of the Indian population resides in villages, where agriculture is the prime occupation. Rainy season is the most productive time for the farmers and at the same time, it is also the peak season of activities for the reptiles and arthropods. The search for food and shelter bring these species closer to human dwellings. The close proximity and survival instincts often result in deadly encounters, often resulting in death of the animal or an injury to the human being. The situation is so gloomy that every year more than 15,000 people reportedly die due to snakebites. However, the unreported estimates are many times more. Whereas, scorpion sting deaths in infants & younger victims have not been included.

Out of the four venomous snakes, only two families, Elapidae and Viperidae, have medical importance in India. This typography of limited species has made the identification simpler. But despite, the limited number, the identification of biting species is still a challenge.

The four major venomous biting species are cobra or *Naja naja* (Linné, 1758), krait or *Bungarus caeruleus* (Schneider, 1801), Russell’s viper or *Vipera russelli* (Shaw, 1797), and saw-scaled viper or *Echis carinatus* (Schneider, 1801). The former two belong to the Elapidae and the latter two belong to the Viperidae family.

Research indicates that specific monovalent ASV is the method of choice, but due to non-availability of standard species identification techniques, the trend is administration of quadravalent Anti Snake Venom (ASV) serum catering to all the four venomous snakes. Which is not only costly, but also inefficient, as the potency of the specific component neutralizing the particular venom is nearly one fourth.

Along with snakes, India harbors many scorpion varieties as well and the most deadly scorpions are those of *Buthus* or *Mesobuthus* genus. It is believed that the shorter the pedipalp, the more lethal the scorpion. The Indian red scorpion (*Mesobuthus tamulus*) is considered the most frightening scorpion in India. Due to its medically important toxic manifestations and number of sting cases, Anti Scorpion Venom (AScv) is
also available in India but, often the case is often considered as a snakebite species resulting in improper medical management. Hence, a proper species identification technique is required.

**c. SPECIES IDENTIFICATION**

Species identification should be part of the primary diagnosis in case of venom interactions. As venom of each species has its unique composition based on habitat, food, size, season and evolutionary experiences. One may find variations in con-species snakes in different geographies and may find similarity in some components in different species. The components of venom work in synergy and thus the constitution of venom becomes important for the snake. This constitution yields species specific manifestations in the victim that can be explored to identify the species.

Many a times, the people bitten by a snake bring along the dead snake for identification, but this method involves a risk of a subsequent bite as well as ecological issues, so it is discouraged. A description by a witness or the patient may not be authentic and thus the species identification has to be done remotely.

Enzyme Linked ImmunoSorbent Assay (ELISA) is a successful technique being used in a number of medical applications. There have been attempts of making a field ELISA kit for snakebites in India too but with limited success [1]. As a blend of electronics and pharmacology; an immunosensors based method was developed to identify the β-Bungarotoxin in krait venom bite site [2]. This method was also had limited success as it was applicable for one species only.

In such a situation, the symptomatic identification remains the only choice currently, which is often practiced by the medical staff, but due to a large number of features, the method requires human expertise.

The symptoms and parameters when joined in order could yield conclusive information about the aggressor species. Identification of
typical con-specific symptoms has been yielding qualitative clues in heuristic methods and severity of envenomation is also estimated with manifesting symptoms.

In order to exploit the heuristic knowledge in one of the proven and efficient decision making as well for better assessment of the severity and reduction of subjective factors, a neural network based method is also proposed.

d. SYMPTOMS AND PARAMETERS

The in vivo venom quantity causes a number of complex reactions in victims’ different systems. However, some commonly observed symptoms have still undisclosed physiology. A number of new and novel toxins are being identified in different species and their in-vitro effects have been studied by different research groups, but there is still a wide gap between the in-vitro analysis and in-vivo symptoms. Along with the symptoms, some body parameters may also change under venom interaction.

In the current context of physiological manifestations due to venom interaction in India, a sample study was conducted by one of the applicants. The information provided by the victim was purely non-classified in nature and did not infringe any copyright or intellectual property right of anybody. In obtaining these data, any change in medical management was neither proposed nor administered. No invasive technique was used and the data collection did not obstruct the medical management. The names and other identifiable details of the victims are not disclosed. The following symptoms and parameters were observed.

i. Fang marks

The venom delivery teeth of a snake are called the fangs (however, herein after, term "fang" is used for scorpion sting as well). Because of its length and grooved shape, fang can work as a venom delivery apparatus in venomous snakes. In the bite marks, the fangs often look broader in diameter and darker if the high concentrations of necrotic constituents are present in the venom. As a result, a thorough inspection of the bite
marks can provide clues about the incidence and the species. Nevertheless, a scorpion sting may also resemble a bite mark, so it would also be covered under this symptom.

**Single fang mark**

It may be possible, that the snake may not have got a chance for a complete bite and with the penetration of one fang, the victim got disengaged. Also, if the bite has been inflicted at some angle, then there may be only one fang mark. It is also seen that due to shoe, cloth or some other hindrance one teeth may not penetrate the skin and there would be only one fang mark. But, in case of snakebite the single fang mark may be accompanied by a few more marks of the other curved teeth or slight erythema around the fang mark due to the mechanical injury. However, in none of the cases in this study, snakebite with single fang mark was observed.

The scorpion causes a sting mark resembling a fang mark. The puncture aperture is often smaller than that of a fang mark. Examination in bright light with a lens can further differentiate the type.

**Paired fang marks**

In majority of the snakebite cases, two distinct fang marks are observed which may be accompanied by few more marks of the other teeth. The paired fang marks are often clearly visible on the limbs in viperine bites and in cobra bite, but, a krait bite may require a vigilant search of the whole body. A number of krait bites marks have been observed on upper torso as well. Because of hindrance or angular bite, there may be inequality in size, shape or other features in the two fang marks.

The Russell's viper may have another pair of fangs growing at the base of the long fangs. This may result in more than two fang marks or even two pairs of fang marks. In a few cases, multiple bites by the same snake also result in multiple pairs of fang marks. These paired/unpaired fang marks would be randomly placed. Incidentally, a repeat sting by a scorpion has not been observed so far.
ii. Gap in fang marks >2 cm

The gap in the fang marks is indicative of the size of the snake as well as the species of the snake. As mentioned earlier, the gap in the fang marks of Saw-scaled viper cases were found to be less than two cm (1.27±.39 cm, 0.5±.16 inch), while that of the Russell’s viper was significantly more (2.07±.43 cm, 0.82±.17 inch). Still, in the event of a large sized Saw-scaled viper or in a very small Russell’s viper bite, the gap between fang marks may infringe the above distinction, but the other symptoms would be helpful in correct identification in such cases.

iii. Local edema

The tissue necrotizing constituents in the venom are mainly responsible for the edema developing. The venules and arterioles in the affected limb may find cleavages and so the blood constituents under higher pressure would escape through the cleavages, resulting in a swelling of the limb.

The edema developing in case of saw-scaled viper and cobra bites adhere to this term in initial few hours. As time passes, the limb becomes engorged, tender and the edema spreads further. However, visually the swelling appears to be centering the fang marks in most of the cases and so it is termed as local edema. Local edema was observed in early cases of heavily envenomed Russell’s viper bites also, which resulted in hyper edema subsequently.

iv. Hyper edema

The Russell’s viper venom contains potent factor X activator. In a complex balance of various factors, the pro-coagulants present in the venom activate the anticoagulation factors and as a result fibrinogen mesh formation is often impaired. However, intravascular coagulation and disseminated intravascular coagulation is reported as a direct action of the pro-coagulants. As a result, fluid accumulates in the damaged vessels
of the limb and for circulating blood, whose pressure is more than the compartmental pressure, some fluid seeps in. In alternate words, it may be defined as unidirectional flow of blood and elevation of compartmental pressure. This results in increased vascular volume and excessive swelling of the whole limb, the entire limb is swollen and the fluid inside has high pressure, it is termed as hyper-edema [3].

**v. Local pain**

The first symptom of pain in case of snakebite is due to the mechanical injury of bite. It is common in both venomous and non venomous bites, except typical krait bite cases. After venom interaction, the presence of hyaluronidase is responsible for a sustained pain due to sensitivity and local cell damage. However, in scorpion stings the nervous hypersensitivity may be liable for the intense pain. As narrated by the victims, the viper venom pains as if thorn has pierced the sting; the cobra venom pains as if red chilly paste has been injected and the scorpion venom induces shooting and burning pain. The scorpion pain is the most intense and as narrated in literature, the autonomic storm may be a prime factor in it.

**vi. Erythema**

The reddish appearance at the bite site is termed as erythema. It may be due to mechanical injury or due to hypersensitive immune response to any antigen. However, in the current group of biting species, only in non-venomous snake bites, erythema was observed due to mechanical injury. This symptom was thus not considered significant in venomous bites and may be useful in ruling out venom interaction.

**vii. Ecchymose**

The local cell damage due to various factors may result in blackening of skin at the bite site. The cobra bite and viper bites may result in ecchymose but not in krait bite. A single dark spot in case of scorpion sting or hymenoptera sting may also be observed. In the event of spider bite, no marked ecchymose is observed at the bite site in almost painless
initial hours. With time, the wound becomes bigger and cellulitis as well as dermo-necrosis spreads. If remained untreated, it may engulf the whole limb.

viii. Increase in Bleeding Time and Coagulation Time

Bleeding Time, observed by pricking a needle in ring finger and wiping blood using a soft cloth till blood oozing is stopped (control 2-4 minutes).

Coagulation Time, observed by running blood in a vertical capillary tube of 1 mm inner diameter). The gravity pulls blood downward but viscosity slows down the speed. If coagulation takes place, the speed keeps on reducing and finally stops to give an estimate of coagulation time (control 6-9 minutes).

The coagulation mechanism in the victim’s body is disturbed by the pro-coagulating and anti-coagulating factors present in the venom. The injected pro-coagulants are sensed by the coagulation mechanism and it reacts against it. As a result, the coagulation is impaired with fibrinogen depletion. Also, due to direct action of venom constituents, the platelets are damaged, which play a major role in the coagulation.

As a result of coagulopathy, the bleeding time and the coagulation time may enhance. It has been observed in viperine envenomation; the bleeding time and coagulation time, becomes prolonged and sometimes may reach infinite value. However, in elapid envenomation and arachnid envenomation, the coagulation system is not much affected and no significant changes in bleeding time and coagulation time were observed.

ix. Bleeding from site

The bleeding from the bite site may signify a number of important factors. If immediately after the bite, blood oozes out, it signifies that fang had penetrated into venous system. It may be indicative of faster circulation of venom as it may have a direct entry in the blood stream. In such a situation, the local symptoms would develop slowly but the systemic symptoms would develop very fast.
In case of viperine bites, even if the venous system has not been penetrated, due to localized destruction of vesicles, cells and muscles, as well as mixing of blood with the lymphatic fluids, the blood may find ways to trickle out of the bite place.

x. Blisters on limb /trunk

The blisters/blebs were observed in cases of Russell’s viper bites with uniqueness that they appeared on the hands and legs only. The exact pharmacological reason of blisters or blebs on the limbs is not known. It is an unresolved mystery why the blisters develop on the limbs only and not on the trunk. However, it may be considered as a typical Russell’s viper symptom.

xi. Hemorrhage

In the current context, hemorrhage (external) refers to bleeding from nostrils, gums, ears, mouth or through some other wounds. In delayed and severe viperine envenomation, there may be hemorrhagic bleeding from various places.

xii. Hematuria

Viper venom is primarily hemotoxic and contains potent cytotoxins. The cytotoxins may deplete the erythrocytes in the delayed and untreated cases as extraordinary intravascular hemolysis. When the erythrocyte ruptures, hemoglobin is released into the blood. The hemoglobin dissociates into alpha-beta dimers and is picked up haptoglobin, a protein carrier, to prevent renal excretion of hemoglobin. Haptoglobin carries the hemoglobin to the liver for further catabolism where the process proceeds as with extra-vascular hemolysis. Under the influence of viper venom toxins, haptoglobin is also depleted, unbound hemoglobin dimers appear in the plasma and beyond a certain level hemoglobin shows up in the urine (which may be called hemoglobinuria as well). Hematuria was not observed in elapid or arthropod envenomation in the study.

xiii. Renal failure
Renal failure or anurea (no urine) was observed in krait bite and scorpion sting cases. According to medical records of past patients, in a few delayed cases of severe viperine envenomation it was observed amid general organ failure. The possibility of enhancement in cardiac load due to renal failure may not be ruled out and it may further affect respiration and the electrolyte levels in blood. For the current context, anurea and oligourea (very less urine excretion) were clued-up from the victim/attendants and confirmed with bladder examination.

xiv. Pupillary dilatation

Pupil reaction to light is amongst the basic observations. In subsist subjects, the pupils react to the sudden exposure to light and the promptness of the retinal muscles provides valuable information about the status of brain as well as the neuronal response.

The elapid envenomation causes a marked dilatation in the victim’s pupil. However, in delayed viperine envenomation the pupil reaction may be sluggish and may be misread as dilated, but it was observed that viperine victims did not present ptosis (as explained in subsequent paragraph). So, ptosis may provide a proper differentiation in elapid and viperine envenomation.

xv. Ptosis/Diplopia

In typical elapid envenomation, the eyelids droop and the victim is often unable to open the eyes. This may be due to dysfunction of the levator palpebrae superioris muscles, which are responsible for the control of upper eyelids. In children, scorpion sting may drive towards hyperglycemic comatose and the closed eyes may look similar to ptosis; hence, it needs be properly identified and correlated with other symptoms specifically pupillary dilatation or mydriasis. In some cases, it was observed that the victims reported dual images or diplopia under elapid envenomation. It might be due to loss of stereo synchronization in the
brain. Waving fingers before the victim and asking for the count may help diagnose diplopia. So, either diplopia or ptosis or both may be considered as a symptom for neurotoxic envenomation.

xvi. Chocking

In krait bite, scorpion sting and in a few cobra bite cases, chocking has been observed. The victim has difficulty in coordinating speech (dysphasia) as well as unable to swallow (dysphagia) its saliva. In supine position, the saliva gets accumulated near the opening of the trachea causing difficulty in breathing. The air released in attempts to speak makes bubbles and froths with saliva, resulting in mechanical obstruction in breathing.

xvii. Colic pain /vomiting

Few krait bite victims complained of stomach ache in early stages of bite, the reason for which could not be established. Some of the cobra bite victims complained vomiting as well. It may be pertinent to mention here, that a number of superstitions related to snakebites are prevailing in villages. Administration of Neem (Azadirachta indica) leaves and Ghee (Clarified butter) in large bolus doses is very common. However, this result in vomiting and it may obstruct the air pathways. Hence, vomiting with Neem and Ghee may not be considered a reliable symptom for the purpose of this work, but colic pain may be a significant identifier.

xviii. Hemoptysis

Delayed presented victims of viperine envenomation complained hemoptysis (coughing out blood). The reason for hemoptysis can be hypervolamia and increased alveolar permeability under the influence of viperine venom.

xix. Glosso-pharyngeal paralysis

(Glossa refers to tongue and pharynx refers to throat). It was observed in almost all the krait bite cases severely envenomed or delayed cobra bite
cases and severe scorpion stung juvenile cases. It may be due to the pre-synaptic or post-synaptic muscular blockade, and in supine position, the tongue may roll back to cause airway obstruction, further reducing ventilation. This condition may be identified, if victim is unable to speak, swallow saliva or make the tongue move.

**xx. Neuro-muscular paralysis**

The complete impairment of movements (paralysis) or partial impairment (paresis) of limbs on voice command was observed in all the krait bite cases and in moderate to severe cobra bite cases. As per the opinion expressed by the attending physicians, the effects may be unilateral or bilateral. In this study, all the cases exhibited bilateral impairments. The children in scorpion sting cases exhibited paresis as well as paralysis. In comatose and unconscious state, the reflexes of neuromuscular activities can be identified by gentle stroking on the limbs and observing the muscular attempts made by the victim. This can be observed by giving voice command to move limbs. In case of unconscious subjects, local unpleasant stimuli on limbs may be given to observe the response.

**xxi. Respiratory paralysis**

Because of the pre-synaptic or post-synaptic muscular blockades, the respiration of the victim is often impaired. The impaired diaphragm movements reduce the inhalation and exhalation, which can be observed by the chest movement. Choking, glossopharyngeal paralysis and neuromuscular paralysis may also contribute in impairment of respiration. It was observed in elapid bites and scorpion sting cases. However, one case of saw-scaled viper (not included in this study) exhibited impaired respiration, few hours prior to death.

**xxii. No local symptom**

It has been observed in many snakebite cases that a good amount of venom quantity remains at the bite site. Hence, except the krait bite cases; almost all the venom interacted cases manifest prominent local
symptoms. However, in krait bite cases, the absence of local symptoms was commonly observed.

In cases of krait bites, minimal mechanical injury, almost indiscernible fang marks, no local edema, no ecchymose is observed. In all the krait bite cases, local symptoms were insignificant and thus absence of local symptoms could be considered as typical to krait bite cases. The absence of local symptoms may be attributed to very small fangs of common krait and dormant hyaluronidase in the venom.

xxiii. Tachycardia

Tachycardia or increased heart rate may be observed due to a number of reasons such as anxiety, fear, choking or slight obstruction in breathing, increased serum potassium level, reduced blood glucose level, fever or some aerobic activities like running or stepping up. Tachycardia was observed in all the scorpion sting cases, four alert and early elapid bite cases and one non venomous snakebite case. If heart rate is more than 100 beats per minute for adults, 120 beats per minute for children and 150 beats per minute for infants, in supine position, tachycardia is considered.

xxiv. Bradycardia

Bradycardia is observed in reduced metabolism, depression, hyperglycemia or impaired cardiac activities. In the current study, cobra venom interactions exhibited bradycardia. If heart beat is less than 60 beats per minute, it is considered as bradycardia.

xxv. Pupillary constriction

The pupillary constriction was observed in scorpion envenomation cases only. In some rare disorders and in opioid intoxications the pupillary contraction or myosis may occur. In one scorpion sting case, there was unilateral myosis. However, in all other scorpion sting cases, bilateral myosis was observed.

xxvi. Hyperglycemia
In scorpion sting cases, as mentioned in literature, the ‘autonomic storm’ may disturb metabolism and the insulin level and the glucose level in the blood may vary with time in untreated cases. As reported by Murthy and Zare, hyperglycemic conditions may develop after minutes to a few hours are elapsed [4]. In cases of scorpion sting cases in the study, abnormally high blood glucose levels were identified. In the remaining cases of scorpion stings, reported within an hour, blood glucose levels were high but not alarming. In this case, a blood glucose level of 150 units (random) is considered as hyperglycemia.

xxvii. Peripheral hypothermia

Due to variations in metabolic levels in different parts of the body, the blood circulation is severely affected. Difference in temperature at the trunk and peripheral temperature was observed in all the cases of scorpion stings. This phenomenon was also typical to scorpion sting cases only. If temperature on the limbs is perceptibly low than the trunk, peripheral hypothermia may be considered.

xxviii. Convulsions

The colic pain, electrolyte imbalance and asphyxia due to respiration difficulty may force the victim to convulse. Some toxic effects of venom constituents on the brain may also be responsible for the convulsion or tremors. The convulsions were seen in elapid bites and the scorpion sting cases.

xxix. Coma

The elapid bites and the scorpion sting cases, if not treated properly in time, may exhibit a condition called comatose or coma (a state of unconsciousness). This may occur if the oxygen supply to the brain is impaired for a significant time or the abnormally high levels of glucose persist for significant time. In coma, some vital organs may be permanently or temporarily be dissociated from the brain and there may be partial or complete, temporary or permanent brain dysfunction. In the
current study only two krait bite cases were observed in comatose condition.

xxx. SpO\textsubscript{2}

The oxygen saturation level in the blood is an indication of the status of the cardio-pulmonary health. In the event of impaired/obstructed respiration or dysfunction of cardio-pulmonary system, the SpO\textsubscript{2} level falls. The SpO\textsubscript{2} is measured using a finger clip type sensor that identifies the optical properties of the blood flow in index finger.

SpO\textsubscript{2} was observed low in the elapid bites, delayed scorpion stings and very late vipherine bites. Sustained low SpO\textsubscript{2} levels may result in irreversible damage to certain brain cells; hence it is a very vital parameter.

xxxi. Age

The age of the victim is a significant parameter in scorpion stings and in snakebites. As the body weight increases with age in the beginning of life, the venom quantity per kg body weight would be less for an adult but would be more for a child. It was observed that the children under the age of five were highly vulnerable to scorpion stings. Then the effect of age is less and less significant.

xxxii. Delay in reporting to medical management

The delay in reporting to medical management refers to the time permitted to venom to remain in the body and work against the welfare of the victim. Thus, more the delay more would be the damage due to venom interaction.

Although, the symptom development and changes due to venom in the body may depend upon a number of factors, including the size and state of the aggressor species, amount of venom entered in the body of the recipient, the proximity of the site with lymphatic and circulatory system, part of the body and the local sub-dermal structure. Still, the delay in
bringing the victim to the competent medical facilities plays a significant role beyond the initial few minutes.

TRAINING AND TESTING

A large number of venom interacted case histories were obtained from various sources. In all the cases the species were identified by attending medical staff. So, sets of symptoms (input for the network) and identified species with severity estimation (output of the network) was available.

From the available history of victims of venom interaction, a set of 21 cases was used to train the Network. These twenty one cases contained venom interacted cases of all the five species with four severity grades (mild, moderate, severe and very severe, quantified as 1, 2, 3 and 4) and one case of false envenomation. The artificial neural network was trained at a given set of inputs, chosen from the case histories of the victims. A number of training sessions were held, till the error of misclassification was removed completely.

From the hospital records, again 34 test cases were picked up and the model was evaluated on these test cases. In all the cases, the model worked perfectly well. No false positive or false negative was identified in the evaluation set. The severity grades were also identified correctly. So, the weights were freezed. These freezed weights were used to develop a software program which had a simpler interface for the users and internal normalization for the numerical values of Age, Gap, SpO2 and Delay.
RESULT

All the 34 cases evaluation cases from the archives yielded correct species. 16 cases, admitted in one hospital during the evaluation process were also considered. The data from the patients were obtained under medical supervision and were fed in the computing device. The software identified the species correctly, The severity estimate was one grade higher in case of three cases, but the attending medical staff was satisfied as it would not affect the medical management. The average time required in obtaining the inputs from the victim and feed in the computing device was 96±26 seconds. And this method did not obstruct or infringed the medical management.

Table 1 - Analysis of the Results of Software with Medical Opinion on Severity

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<thead>
<tr>
<th>S.No</th>
<th>Name of the Species</th>
<th>Number of cases</th>
<th>Software Agreement with Medical Opinion on Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Naja Naja</td>
<td>8</td>
<td>100 %</td>
</tr>
<tr>
<td>2</td>
<td>Bungarus Caeruleous</td>
<td>8</td>
<td>100 %</td>
</tr>
<tr>
<td>3</td>
<td>Echis Carinatus</td>
<td>11</td>
<td>100 %</td>
</tr>
<tr>
<td>4</td>
<td>Russell’s Viper</td>
<td>2</td>
<td>100 %</td>
</tr>
</tbody>
</table>
SUMMARY OF THE INVENTION

This method is an attempt to utilize the knowledge of a set of symptoms and their species specific manifestations. Various models were tested for optimal performance and finally a specific model was chosen, which perceptron type Artificial Neural Network is.

The proposed Model is based on physiological manifestations due to venom interaction. The Network takes into account the manifested symptoms as inputs, which are processed in a weight matrix. Weighted summation of presence and absence of manifestations add in Perceptron Network. The probable species is given high score and improbable species is given low score.

So, to make this method quantitative, most of the symptoms are judged by their presence or absence. The binary classification of most of the symptoms simply reflects as either “0” or “1” by the network. However, some factors like age, oxygen saturation and delay in bringing the victim to the healthcare centre (hereafter called delay) affect severity, based on their respective numerical values.

The output of this model (species code and severity), does not exhibit the synergistic effects of a group of symptoms or conditions (hereafter called inputs). So, each input is treated as independent of the other. This is important from the point of view of expansion of this model, if more
inputs and other species are to be included at later stage (for example in Thailand where more than 10 venomous species exist or in Australia, where more than 14 species venomous species exist).

Age, Gap in Fang marks, Oxygen saturation and delay are in numerical values. Further, these inputs are normalized between 0 and 1 using specific normalization relations based on experiments and experience and fed at respective input nodes

Various normalization relations are as under

**Normalized Age factor** = \( \frac{1 - \text{Age}}{\text{Age} + 5} \)

...(1)

Where age of the victim is in years,

**Normalized Gap** =

1, If Gap in Fang Marks > 2 cm

0, If Gap in Fang Marks <= 2 cm.

...(2)

**Normalized Oxygen Saturation** = \( \frac{1 - \text{SpO2}}{100} \)

...(3)

Where, SpO2 is in percent, normal value is 100%.

**Normalized delay** = \( \frac{\text{delay}}{\text{delay} + 2} \)

...(4)

Where, the delay is in hours

Rest all the inputs are either binary or multiple choice. Each yes is equal to “1” and each No is equal to “0”. In case of multiple choice inputs, each selected choice is treated as “1” at the specific input node whereas non selection carries a “0” at that choice. A bias node is provided to adjust the offsets developed in the training phase.
So, all the inputs are converted into values, ranging between 0 to 1. This input vector is fed into a perceptron type Artificial Neural Network. The perceptron model simply multiplies the input vector with predefined weights and provides summation of the product at six specific species nodes.

Each species node refers to one species and the output numerical value refers to the possibility of envenomation by that species. If the node’s value is negative or zero, it implies no possibility of the particular species.

The output node receives information from the previous stage. The output of the species node score that is highest is chosen as the severity index and the species corresponding to the node that yields the highest score is identified as the assailant species. At the output, if the severity grade is fractional, it is rounded to nearest integer. In case, the output exceeds “4”, severity grade is brought to “4”, thus giving a limited and definitive output.

Numerical value “1” refers to mild envenomation, “2” refers to moderate envenomation, “3” refers to severe envenomation and “4” refers to very severe envenomation.

In case there are more than one species nodes yielding positive values, then the highest value and the respective node is considered for the purpose of species identification. So this method would demonstrate a clear and definitive result. There are possibilities that due to incorrect inputs, there may be some misclassification, in such a case of doubt, the procedure may be repeated with correct input and fresh result may be obtained.

References

1. Z. E. Selvanayagam, S. G. Gnanavendhana, K. A. Ganesh, D. Rajagopal and P. V. Subba Rao, "ELISA for the detection of


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