

Automated Eye on Nature (AEON) and the Were-Tigers of Belum

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Abstract. Environmental biodiversity, of flora and fauna, is a direct indicator of the general health of the environment and surrounding ecosystem. Ecologists expend a great deal of time and effort collecting this raw data, targeting key biotic indicator taxa, also called *bio-indicators*. However, methods for collecting bio-indicator data largely remain a laborious, time-consuming and manual process. This paper proposes a visionary idea of developing an automated global sensor network for the collection of key bio-indicators, which is an inherently diverse and complex problem, spanning environmental extremes. We outline the ideas for our Automated Eye on Nature in the first part of the paper and then explore an application of the technology in our fictional prototype. The prototype explores potential social and cultural issues involved with deploying this technology which highlights possible complications, which might then be considered and usefully fed back into the initial design phase. We conclude with some open questions that consider how ecologists and other scientists might exploit the capabilities this envisioned technology provides.

Keywords. Sensor Networks, Conservation, Animal Behavioural Research, Behavioural Analysis, Culture

Introduction

The environment and the world we inhabit today is perhaps the most precious gift we have to pass onto the next generation. Those who will inherit tomorrow's environment and tomorrow's world will no doubt question how we managed their legacy. To help us understand the complexities and sensitivities of our finely interwoven eco system and our effects on that system, we need to build accurate models from which we can derive theory, make predictions and define policy. A complete model would measure all forms of environmental data, both flora and fauna, such as plants, animals and micro bacteria, across the world, measured at frequent intervals, ideally in real-time [1]. However ideal this maybe, it is currently very impractical, there are too many species to measure and monitor, and data collection is often tedious and time-consuming and on the whole, carried out less frequently than desired.

Since it is impractical to consider all biotic taxa for measurement, ecologists have identified a small number of key indicator species, namely, Plants (Trees), Bats, Birds,

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Aquatic Macro Invertebrates, Moths, Ants, Figs & Frugivores, Dung Beetles, Stingless Bees and Large Mammals, ordered for their importance as a general environmental indicator [2]. Their sensitivity and stabilities to environmental conditions such as air pollution, climatic variation, foliage-densities and so on make them a practical bio-indicator, moreover, they are present, in some combination, across all continents and environmental conditions. This commonality has the advantage of facilitating a common frame of reference for data analysis.

Data collection typically involves a protracted manual process; a good example is the collection of moth data. The collection of moth data requires the ecologist to physically travel to the area of interest, assemble the collection apparatus (light-trap(s) in this case) either camp overnight, especially if the area is in a remote location, or leave and return at a later point, the raw data needs sifting and cataloguing by an expert taxonomist, picking out the targeted moth species from the other collected moths and insects, only after this process can the processed results be used for modelling purposes [3]. This process typifies bio-indicator data collection and is the process our proposed system is designed to automate.

1. An Automated Global Sensor Network for Real-Time Bio-indicator Collection

Our proposed system is designed to automate the collection of key bio-indicators. The global vision for this sensor network is illustrated in figure 1.

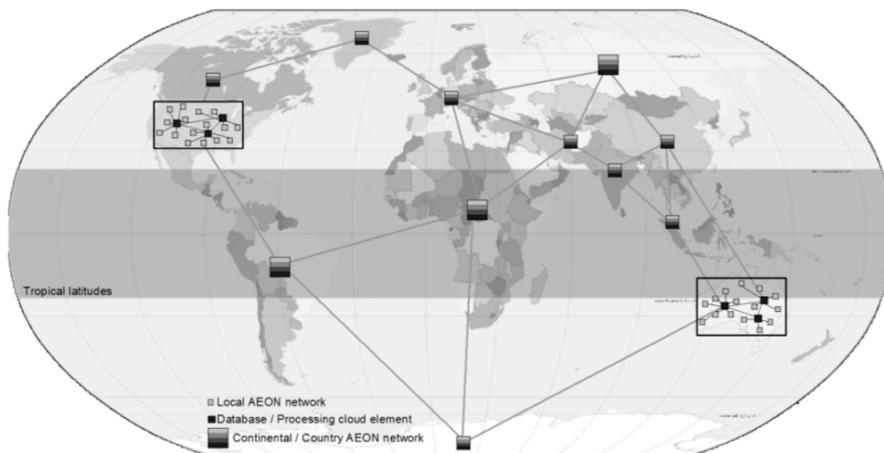


Figure 1. Conceptualised view of the Automated Eye on Nature (AEON) – a pervasive, global, sensor network of ruggedized, low power, low maintenance sensor nodes remotely connected to the internet, delivering raw and processed data to a distributed database network for processing by the cloud computing network. Real-time statistics available via the web based GUI.

We are currently developing a sensor node for the automatic monitoring of moths in urban and tropical forest environments. Our sensor node features an image sensor which integrates with a modified light trap. We expect a preliminary set of results later this year. Moreover, this network could be multitasked for other conservation purposes, monitoring endangered species for example, such as tigers.

2. AEON Fictional Prototype: The Were-Tigers of Belum



The screen flashed. Raja jumped back to his seat. He selected the hotspot on the screen to get the readout on it.

Just about then, the sun in the between the hills began to show itself, casting longish shadows on this nondescript shop lot in the leafy suburb neighbourhood of TTDI, in Kuala Lumpur. The plain signage on the door simply read A.E.O.N. A svelte feminine figure strode purposely towards it.

The door swung open, and Kim walked in for her turn at the shift. Raja called out to her.

"Hey Kim, take a look at this."

"What! ... not even a good morning greeting?!"

"No time for that, we've got a trace on our bandit. Drop your stuff, come have a look."

Raja pushed the data onto their main projector screen. Four big monitors filled the wall in front of them, showing the real-time status of the sensors projected on a map covering most of East Asia.

"Kim, take a look at this, bandits are hot."

"Doesn't look quite right, look there is another hotspot ..."

"Aaawww man, the sector is lighting up, what the heck is going on?"

"We have, like, 11 spots on in the sector, is that even possible?"

"Oh yeah, could this be a system error ..." Kim wondered aloud.

"Let's have a look at the other regions and sectors... let's see... Hupingshan nothing unusual, Kerinci, Berbak, Kulen Promtep, all fine... generally nothing unusual anywhere, except right here in Belum-Temenggor, Perak... "

"Okay.... let's check the health of the roamer bots and server units. Mmmm... looks like it's centred around Kampung Sungei Alam..."

"Hey, is that where the tiger incident happened last month... where that tiger attacked a villager?"

"Yeah, we sent a team to investigate... we found that the tiger was wounded because it was snared in a trap, the tiger was still conscious when the villager approached and it attacked him. The news media made up a story to look like the villager was somehow a hero, for fending off an attack, but we suspect that is was the villager who most probably set the trap in the first place and he was returning for his spoils. You know, a whole tiger can fetch you up to 150K on the underground markets, and that's in U.S. dollars, almost every part of a tiger has value now-days, not only the skin..."

"Well, it's the middle men that take most of the money anyway, the poacher takes home a few hundred ringgit only, but still, I think even that amount of money is tempting to them... but getting back to these hot spots... what do you make of it?" asked Raja.

"I am getting the data... the server is reporting unusual activity, that's why what triggered the alarm... here is what I have from the roamers, looks like they have caught some tiger activity. Based on the profiles the AEON AI has learnt, the tracking data indicates abnormal gait, which means that the tigers are not moving about normally."

As you know the video understanding AI has the ability to distinguish normal tiger gait, so that it can tell if the tiger is wounded, or being dragged or carried. Eleven of the roamers belonging to server unit 21 reported the same abnormality, and all within the 10 kilometre block. This is highly unusual... unless there is a tiger summit somewhere!!” said Kim excitedly.

“So we have 11 wounded tigers in the vicinity? We don’t even know if there are 10 tigers in the area in the first place!! How could there be 11!?!?” Kim frowned, and rubbed her forehead.

“Maybe we should alert the *Perhilitan*¹ rangers?” Raja looked for the number and picked up the phone to make the call.

Raja wanted his shift to end, as he was really looking forward to a shower and his favorite *nasi lemak*².

“Uh, Raja, just hang on, we have to be certain first. Too many false alarms will get us hanged, and left to dry. Are we certain the software is working?”

“Aw, c’mon, we’ve spent hours testing it, we know it works, that’s why we released it on the system...”

“Yeah, still... doesn’t do any harm to double check...”

“And let those poachers get away?” Raja shook his head.

“This won’t take long; let’s see if the original video stream is still available.” Kim keyed feverishly, knowing that time was of the essence.

“Forget about the video, the recording is not stored, you know the bandwidth is too expensive, that’s why...”

“Damn, you’re right, well, we need the raw algorithm data then. Uh... let’s see I need the recognition raw data... and the gait recognition data. From the gait data, I can reconstruct the individual locomotion of each animal with Markov probabilities from the dataset.”

“What about the detection and recognition data? Can you be certain that the algorithm has detected it correctly in the first place?”

“How can we tell, anyway? The original source is not kept.” Kim turned to look at Raja, puzzlingly.

“Pass the data to me... you work on reconstructing the gait data.”

“Ok, I am already running the reconstruction; I just sent the rest to you.”

Just then, Kim let out a whistle, and called out to Raja, “Look at this model animation of the gait, Raja, they look weird, certainly not a normal gait of a tiger”.

“Oh my god, I don’t believe this.” Raja gasped.

Then he continued, “You know, Kim, the natives believe that a tiger-spirit roams the forest. They believed that the tigers are the guardians of the forest, and its protector. These spirits are the re-manifestation of their ancestral spirits. To see them is an occurrence of dire portent, a harbinger... It is also believed that these spirits can be called into existence by the *bomohs*³, or by some momentous future event... usually a sign of something that is going to happen, be it good or bad.”

“Surely you don’t believe in that stuff, anyway, what has it to do with this?”

“Well what if it’s true, there might be something to it? What if we have triggered something in the deep forest, our machines have penetrated into parts of the forest

¹ Department of Wildlife

² Rice cooked in coconut milk, served with peanuts and anchovies

³ Traditional healers

where nobody has ever gone before, what if we have violated the sanctity of the tigers most ancestral place and awakened the *semangat*⁴ of the forest!?”

“Aw c’mon Raja, stop pulling my leg, this is the 21st century, you are a good scientist and you are still talking about spirits? What have been smoking lately?”

“What does this century have to do with anything? Don’t you see all this *datuk-datuk*⁵ by the roadside everywhere, with all their elaborate shrines and offerings? Rites are still being performed prior to important events.”

“And ... your point?” asked Kim.

“Look, you said those are not tiger-like gaits, yet the software has identified them as a tiger like gait, it is a tiger that does not have a tiger like gait. We know our software and AI works, we tested it, rigorously. So, what does that tell you? Do you know that it is believed that the *bomoh* with sufficient *ilmu*⁶ can transform into were-tigers. These were-tigers can be recognized by the lack of the groove in the upper-lip and by their gait. This is because their heels are reversed! Don’t you see, this is precisely what the software has detected, the unusual gait is caused by the reversed heels, can’t you see it in the sensor pattern on the screen?”

“Are you seriously suggesting that we are tracking were-tigers?” asked Kim, incredulously.

“Well...” Raja, confused, stalled as he couldn’t really put in a satisfyingly coherent reply.

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When he was young Adi liked to listen to the stories told by his uncle. Glorious tales of the wild, of days bathing in the river, eyeballing crocodiles and waiting half submerged in the muddy banks - and of days killing wild hogs, muntjac and *kancils*⁷. It was an even fight, of man against animal. Those days are, however, over. Where were all those animals now? Gone, run over by trucks, burned by bush clearings, starved by hunger, those were their fates – a fate shared and intertwined with the natives that lived besides them, on land that once nourished all. And those thoughts leaned heavily on Adi’s mind.

Today Adi prepared to go into jungle. He considered himself fortunate to have this opportunity. He no longer would have to spend weeks collecting shrubs and honey from the jungle for a meagre sum. No, this time, he thought, he has struck it big. No doubt there are things to be wary of, but he would not be afraid. Once he was nearly killed by a riverine croc, but he fended it off. The talisman he was wearing protects him, he believed. The talisman, given to him by a *bomoh*, was made of bones, shells and roots, but most importantly it contained tiger bones and teeth. Not just any tiger bones, but the star-shape sengkul bone that is said to contain the tiger’s strength, a magical piece of bone that makes the owner invincible, like the tiger. It will be no different this time, he thought.

“*Bang*⁸, your friend, Batin, is here,” his wife, dressed in a traditional sarong, called out.

Adi, gathered up his snares, *sumpit*⁹, *parang*¹⁰ and dagger and went out front to join Batin, a long-time childhood friend.

⁴ spirit

⁵ guardian spirits that resides in trees, ant hills, caves, riversides and in stone formations

⁶ skill and knowledge

⁷ mouse deer

⁸ brother, term of endearment

⁹ blowpipe with poisoned dart from the Ipoh tree

“Why the look on your face, Batin?” Adi queried, thinking that his friend might back out.

“The elders have always been saying, we should not disturb the order of the forest,” said Batin.

“I used to be able make a living gathering *petai*, *tongkat ali*¹¹ and *tualang*¹² honey, but now I have to go deeper and deeper. Even cultivating *ubi*¹³ is difficult. The river is often muddy, and often times barely trickling. I even tried becoming a fisherman, borrowed money from Man, you know, but with the wetlands gone, we have to go further in the open sea, but with a small boat, what can I catch?”

Adi, looked at his friend, hoping that he will understand.

“We cannot live like this anymore, look around, we barely have enough food to eat, the forest thins out, the soil is barely sustainable, what do you want me to do Batin?”

“It is true, we live in a dilemma, I agree, sometimes what the elders say are not right, but still, they are like the pole star, they point to the way, even if they are not right with every detail, they are our soul, where would we be without a soul, a spirit?”

“Batin, you speak like a shaman, will you help or not?”

Batin grudgingly mumbled a reply, only because he did not want his friend to be in trouble, and figured, he still can be persuaded, perhaps wishfully, not to go.

They trudged through the thick humid jungle, slashing their way with their *parangs*.

Occasionally, the calls of the wild macaques and *siamangs*¹⁴ could be heard, amidst the hoo-hooting calls of some unidentified animal, rising above the incessant insect hum. Shafts of the tropical light penetrate the thick foliage, the sun dappled-leaves sway, rustling when a deer or a squirrel scampered away. The forest is a dangerous place for a modern man, but to the *orang asli*¹⁵ it is a door to a magical realm filled with spirits. The *orang asli* is always respectful with the natural order and believed that arrogance will be repaid with arrogance, and sometimes death. Despite what they were about to do, Adi and Batin, had been respectful in their behaviour and actions as they both journeyed into the depths of forest.

They reached a spot deep in the jungle where they found tracks. They followed the tracks until they found a suitable spot for their snares. As they prepared to lay out their snares, they heard a noise; a gentle rustle of the leaves.

In the forest, it is bad luck to see what you are not supposed to see.

They both turned, shocked, they stood rooted.

In the next moment it was gone.

“Adi, did you see?” whispered Batin.

“Yes,” answered Adi, equally in a whisper.

But Adi was shaking. Without a word, noiselessly, they packed their snares.

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Raja and Kim stared at each other, in a room surrounded by computers, warmed by the flickering glow of pixels from the various monitors.

“Why is it not possible, Kim? With our technology we got into the forest, deeper and longer than anyone before. Too bad, we don’t have the video footage.”

¹⁰ Malay machete

¹¹ (lit.) Ali’s stick. *Eurycoma longifolia* is a flowering plant with reputation as an aphrodisiac

¹² a tropical rainforest tree

¹³ sweet potato

¹⁴ *Symphalangus syndactylus*, a tailless arboreal gibbon

¹⁵ natives

“Whoa, Raja, soon, you will be saying we found bigfoot!”

“Why not, if we had been in *Endau-Rompin*, we might well have found bigfoot!”

“Raja, you are talking about a totally different order of things, in the realm of spirits and magic!”

“You don’t believe in spirits, Kim?”

“I have seen no proof...” Kim said, not willing to concede.

“Well, you yourself have provided the proof. You believe that one man died and was resurrected, I believe in tiger spirits, what’s the difference?”

Kim let that remark pass, not wanting to side track to another contentious topic.

“Not so fast, Raja, you are making a wild leap here. I only showed that the gait is unusual, you are making a wild conclusion. Occam’s razor, you know.”

“Ok, Occam’s razor. What else could it be?”

“I don’t have any idea at the moment, I grant you. Well, let’s see, it’s is not a tiger-like gait, and neither is it an animal or wounded animal like gait... so... I conclude it is not an animal. “ Kim frowned in thought.

“You are right, not animal, not eleven of them, but the software identifies them as tigers,” agreed Raja, and quickly declared, “those are eleven were-tigers.”

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On the way back both men, Adi and Batin, kept their silence, neither one willing to openly discuss their experience. They did not discuss the incident in the days that passed, even with their wives.

As the days passed, Tijah, Adi’s wife, could sense that something was not right from the day when both of them returned in pensive and subdued state. She couldn’t understand his reluctance to discuss what was bothering him.

Finally, Tijah, summoned enough courage to ask him.

After a momentary pause, Adi looked straight into Tijah and answered, “Yes, why did I leave the jungle and leave empty handed? I left because I saw something that I should not have seen, and I probably should not have lived. We’re lucky to be alive.”

Tijah asked gently, “Was it the talisman that protected you?”

“No, no, it wasn’t. It couldn’t have been, it just stood and stared, you know, just stood there, like it was warning us...”

“Why did you think that you were unharmed?”

“It was not there to harm us, but to warn us. We have lost the belief that the spirits of our ancestors, our fathers and forefathers lived in the spirit of the tigers of the wild. We used to believe that the incarnation of the spirits guards the order of both the jungle and the village. They are the guardians, the stewards, the protector, it was their right, and we were intruding. It was there to reawaken me. Now I truly believe that tigers have special powers – *kesaktian*¹⁶ – that allows it to control the forest. I now think that the ancestral tiger spirit is sent over to watch over our moral well-being of the village and that we conduct ourselves according to the *adat*¹⁷.”

Adi continued, “As spirits of our ancestors they should be honoured and revered, they shared a human soul. Do you see now? This incarnation of ancestral-spirit guards over us, protects the order of the forest, regulates our village. And this is what you must know. Or else we would have lost our soul. And our meaning in everything.”

“The events jolted me back to the traditions that I was brought up with. We believed, but in the transition and other influences we lost that belief. But, as I

¹⁶ magical power

¹⁷ traditional customs and law

discovered yesterday, it was always remained inside us, submerged. We wanted to believe, yet we were swayed by all the shiny modern materials. You know, the forest does not really belong to us; rather we belong to the forest. When I saw it, I knew that it came to warn us, warn us not to step further into the dark hole. I could have died there and then, but I lived, we both lived”

Tijah remained silent, desperately absorbing all that Adi said.

Something within her lit up, she held out her hand to Adi, drawing them together, they hugged and looked outwards, towards their new long future.

The 195 year old Church of Immaculate Conception is just a stone’s throw away from the *Pulau Tikus*¹⁸ market. Behind the market, there's a row of double storey pre-war Straits Chinese shop houses facing Burmah Road. Further along the road leads to the famous Gurney Drive that fronts the beach. Dotted along the neighbourhood are gourmet cafés, coffee shops, eateries and pubs. A fair share of bungalows, mansions, condominiums and colonial buildings complete the area.

In the grounds of the church, there is a plaque that is inscribed with these words - "In Memory of Francis Light, Esquire, Who first established this island as an English Settlement & was many years Governor. Born in the country of Suffolk in England and died October 21st 1794." The descendants of Francis Light’s mistress’ family still make *Pulau Tikus* home.

Sequestered from the daily hubbub, traffic and noise, in one the pre-war houses behind the market, Paul Chan, was talking business on the phone in his broken English. Shafts of mid-morning sunlight streamed through the air-well in the roof and wooden louvered windows, lighting the interiors of rosewood furniture and blue *Nyonya*¹⁹ ceramic wares in showcase teak and *chengal*²⁰ cabinets. The entire floor was lined with the original antique geometric patterned terrazzo tiles, while smoke and aroma from sandalwood joss sticks wafted in from the ancestral table.

"*Datuk*²¹, don't worry lah. I got all the people *kau tim*²² already. Yah... lah... definitely, *kau tim kau-kau*²³. You didn't see the newspaper ah, I got picture with the minister, all smiling and happy. I got all of them officials lah, customs, *Perhilitan*, everybody, all under my little finger... haha... can... surly can one, even the TRAFFIC people, yes... already, already, settled, *Datuk*. I can throw in a few pangolins and marbled cat, or even a sunbear for him. "

Paul Chan likes to boast about his ability to get what you want. He is not a big guy but rather stocky bespectacled with a fashionable horsetail. Sometimes his bluster precedes him, and he can strong arm you, possibly with the help of some of his mates. Nevertheless you won't call him a gangster, and you won't think him one.

"AEON? What, those automated eye in the sky guys, sh*t! Huh? Not in sky? Eye on nature? ok... whatever lah, Aiyah... you don't worry about them, they are like little boys. Eye here or there, or where, I don't care, I got bigger eyes, ears, legs, hands, bodies everywhere, no need in sky wan, *Datuk*, I already got their secret, easy. *Datuk*, this time, I *taruh*²⁴ them *kuat-kuat*²⁵ wan, you don't worry. No give chance, but I give

¹⁸ (lit.) rat island

¹⁹ Straits-born Chinese women who are partially assimilated to local culture speaks a blend of Chinese, Malay and English

²⁰ *Neobalanocarpus heimii*, type of hardwood

²¹ honorific non-hereditary title conferred by head of state

²² (slang) fix

²³ (slang) thoroughly

²⁴ (slang) fix

²⁵ (slang) thoroughly

little surprise warning to them first. *Kau tim, Datuk*, correct... correct... correct. No worries, settled, yes, correct.”

Paul paused as he listened to instructions from his benefactor and co-conspirator.

“Ok... ok, Datuk, when you come Penang? You come I buy you drinks with sharksfin soup, still got the XO from the last time, or you want some sweet *nyonya kuih*²⁶, or hot tomyam, you know... something hot and spicy and young... haha... haha... ok, ok, can... can... ok... ya ... ya... can do... lah... ok, settled, ok, can... thank you, goodbye.”

Paul put the down the phone. Piled on his table were stacks of National Geographic and Asian Geographic.

“Ah Wah, did Mat and the guys do their thing?” asked Paul.

“Ya got, boss,” answered Ah Hwa.

“Got what? What did they do?”

“As you tell us, boss, you told us to go find some woven tiger print rug, take to forest, right? So we go get lah. We then go cut to fit on the gang in Perak. ”

“Didn’t I tell you to get 10?” Paul was getting all riled up.

“Boss, difficult to get lah, the tiger prints also endangered,” said Ah Wah with a dangerously weak attempt at humour.

“So did you go get 10?”

“Ya we got 10, but along the way to Perak and the forest, there was heavy rain, some of them was ruined, and couldn’t be used anymore,” replied Ah Wah.

“You useless idiot! Why are you wasting my time and money!! ” said Paul, now, really annoyed.

“Boss, I think is enough lah, we already took the tiger prints, put on Mat in the forest, we got the AEON trackers going wild. We did them already.”

“So how many of the guys you got as tiger?”

Ah Wah, kept silent, thinking desperately about how to wrangle himself out of answering.

“Wah... so how many?”

“1”

“1?”

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19th July 2010 The Straits Echo

Man mauled by tigers, NGO blamed and urged to withdraw

By Mahathir Razak

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IPOH: An unidentified man who was said to be foraging in the forest was found dead in the Tapah Forest Reserve. He had several gaping wounds on his back and suffered injuries to his hands and legs in his attempt to defend himself.

A spokesman from the Perak Wildlife and National Parks Department (Perhilitan) said that they will send a team to check. State Perhilitan director Saiful Baginda said that tigers do not usually attack people as they are normally reclusive animals.

“A tiger might have attacked because it was in pain or wounded but 10 is highly unlikely, if not impossible, they are not pack hunters,” he said yesterday.

Meanwhile a member of the foreign funded conservation NGO Automated Eye On Nature (AEON) spoke on conditions of anonymity said that they have spotted multiple

²⁶ Straits Chinese delicacies (edible)

suspected tiger activities in the area yesterday. He further added the activity was unusual because such high levels of tiger activity have never been observed or recorded before. He also noted that the area was not on the usual tiger tracks.

The president of association of traditional healers, Datuk Khairul Nasri, has called for AEON to withdraw from the forest and the country. "The forest does not like being observed whether by human or electronic eyes. The spirits of our forefathers have been intruded upon and are angry" said Datuk Khairul Nasri.

The AEON president, Dr Francis Kathigesu, issued a brief statement denying that their activities interfere with the forest in any way, and could not possibly have been the cause of the attack.

3. Reflection

In this paper we have envisioned a global real-time sensor network for the automated collection of key bio-indicator data, our so named Automated Eye on Nature (AEON). Although AEON is primarily to collect biotic taxa data to model the biodiversity and health of the environment, the data could also be used to drive real time environmental models to help us better understand the complexities of our ecosystem. Our fictional prototype explored one such extended usage, where the taxa data from large mammals, tigers in the story, was used to drive AI gait models which in turn enabled identification and behavioural tracking of tigers. This type of tracking is being actively researched, although using more conventional methods [4, 5].

While there are many technical challenges to overcome before AEON becomes fully realisable, as technology continues to rapidly mature, we think that AEON is today a viable possibility, both technically and economically. This prospect raises a few forwards questions, or scenarios, for example, what if we had AEON today? Would it be useful? How would it be useful? What could it show us? What might the real-time data models reveal? What new theories might emerge? While we put these questions to the ecologists, and we hope to get some interesting views, in the mean time, our aim is to build a local AEON prototype, in collaboration with the local forestry research and management organisation, to automatically monitor moths in real-time within tropical urban and forested environments.

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