Driving – An Information Management Cognitive Approach. A discursive overview study: who should drive man or machine?

By

David C. Westlake, MSc; C.Eng; M.I.Mech.E; M.I.E&T.

Retired Lecturer from:-

Information Management Systems Cognate Group,

School of Computing,

Faculty of Engineering and Computing,

Edinburgh Napier University,

Edinburgh.UK

d.westlake@napier.ac.uk

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Abstract

This discursive overview study applies information system [IS] and information management [IM] theory to computer cognitive computing {CC] technology and human intelligence [HI], driving asking which should finally prevail. These advanced systems are being developed to address driving conditions, aid human abilities and utilise foreseeable changes in technology over the next 5, 10 and 15 years.

System theory reveals the logic underpinning the ongoing trend towards fully autonomous self-drive vehicles. The study identifies several implications, not all beneficial, about the gradual introduction of these semi-automatic and automatic driving systems based on CCT. Recent CC references are found lacking thus more facts about these CC system architectures need publication for expert peer review. The study finds that the introduction of CC needs to be properly managed. CC systems are evaluated and several problems are identified about their performance. The literature research identifies several important information management and system theory constructs are missing. The study applies system theory research methodology and by this means develops the Driving – Information Management Approach taxonomy, basic HI-CC technology driving information management system concept diagrams and 'Turing-Test' criteria. The latter is defined in order to determine when or if a successful sentient CC-HI system has been built.

The study identifies the need for more technical development to provide better 'driver-assist' safety systems. These would provide Expert / Decision support Systems [DSS] that can actively involve the driver's mind in the decision making. Counter-intuitively the study recommends these developing CC systems need to involve, not exclude, the driver's mind with the driving task and process. This is achievable by use of verbal commentary given either way by the CC system or human driver. This is in order to achieve effective improvements of human intelligence based driving and ensure the skills do not atrophy; an inevitable outcome that would otherwise occur when the human driver is expected to take over if the CC malfunctions or is unable to deal with unusual conditions. It recommends in normal use the human driver may take over control from and hand back control to the CC system, by applying a defined protocol. Sentient CC will require verification at annual MOT checks.

More research is needed in order to certify that robust software and resilient fully automatic 'self-drive' automotive systems are buildable, as present system design, engineering knowhow and build methodologies are not adequate for the task of validation to meet ISO26262 requirements in an acceptable time-frame.

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Keywords:

Driving cognitively

Information Management

System theory

Autonomous vehicles

Highlights:

- Discursive overview study, who should drive, man or machine?
- Modest CC driving development progress. Peer review required of software and system architecture. Needs managed introduction.
- Driving IM Taxonomy, HI Driving IM system & 'Turing Test' criteria defined for expert sentient 'CC-HI' system
- Set up and maintain effective communication channels between CC and HI with concurrent verbalisation
- The design, engineering and also the manufacturing technology needs much more R&D in order to build CC technology driving systems

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Glossary of Terms:

ITS Intelligent Transport System

IM Information Management

IS Information System

ICT Information Communications Technology

DSS Decision Support System

ESS Expert Support System

ABS Antilock Braking System

TCS Traction Control System or sometimes identified as

SCS Stability Control System

WM Working Memory

DAS Driver attention assist system

CC Cognitive Computing [technology]

HI Human Intelligence

AI Artificial [neural network] Intelligence

FL Fuzzy logic

CTL Conventional temporal logic software

HCI Human Computer Interface

GP Generic Programming

CASE tool: Computer Aided Software Engineering [workbench]

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1.0 Introduction

This discursive overview investigation is about how technology is addressing driving conditions currently being faced and likely to appear over the next 5, 10 and 20 years. Thus managing more effectively by use of technology, driver error, congestion, pollution, noise, road layout, surface traction, weather and road traffic conditions. Driving–assist and further autonomous driving technologies are undergoing extensive development with some journalists arguing for the eventual complete non-involvement of the human driver as a panacea for all driving problems. The rationale behind cognitive computing vehicle systems development is explainable by system theory. This discursive overview study asks which cognitive approach is superior as the eventual outcome: driving done by man and or by machine?

Applying information system [IS] & management [IM] theory as a research methodology helps investigate how well vehicles are controlled by cognitive computing technology or human driving. A literature review [LR] and discussion is conducted of published research briefly about human intelligence driving [HI] then in more depth cognitive computing technology driving, shaping further investigation. In outline terms cognitive computing comprises of artificial neural-network, fuzzy logic, generic programming and driver-assist safety systems. They are not all the same and are at different stages of development.

The nature and abilities of human drivers are given initial evaluation defining the scope of the problems cognitive computing driving technologies are trying to solve. Cognitive computing driving systems are already at the prototype stage of development. Much more work is still required but the developmental pathway and clarity of the final deliverable objectives are far from clearly defined. To aid system requirement definition, sentient 'Turing Test' cognitive computing – human intelligence achievement criteria, a driving IM taxonomy and Driving IM system concepts are defined and developed. Initial conclusions are drawn and recommendations tabled about its future development pathway for cognitive computing – human intelligence autonomous driving systems over the next circa 20 years.

Specific detailed research into the highly complex technical scope of these cognitive computing systems and sub-systems is not part of this Driving - IM overview paper. This is not ignoring the vital importance of this ongoing work. The demanding challenges involved in comprehensive design, detailed engineering and manufacture of all the components and subassemblies et al including robust software development, should not be understated. New

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techniques are required from research teams in order to achieve delivery of robust safety and security enabled ‘self-drive’ vehicles. (Edwards, 2014). A means of achieving this is discussed and outlined later in 11.1 and 11.2.

2.0 Research methodology – Applying System Theory: Identifying the rationale behind vehicle and driving technique development.

Information management methods and related systems are all constantly evolving. The logic is as follows. System theory recognises closed mechanistic or deterministic systems are predictable but inflexible. Open social flexible systems involving people, make system behaviour less predictable but adaptable. According to system theory, adding people makes closed systems into larger open systems and therefore less predictable. The driver controls the vehicle system: ergo the result is unreliable. Consequently, the trend in research and development is towards deterministic systems. The necessary changes will eventually produce deterministic vehicle systems that are more reliable and predictable than those involving inept people. This is in order to offset declining or poor driving standards found in non-expert drivers.

Whilst this logic may initially appear sound, be supported by people that prefer to be or should be driven rather than drive themselves, this ‘time-line’ does not allow sociological ‘wants’ and ‘needs’ to be satisfied. This is required by open system theory. A ‘want’ is the personal fulfilment of the ‘inner-being’ when achieving a synergy between ‘man-and-machine-in-harmony’. A ‘need’ is following a bad experience or undergoing an epiphany, allowing a pathway for the sinner to achieve redemption by improving their driving. Deterministic system developments will generate further human ‘needs’ that must be satisfied. Human skills will naturally atrophy or degenerate into a state of disorder without vital maintenance. Inputs must continue to the social (open) system in order to preserve the capability to drive safely when required, on failure, malfunction or wish to override the deterministic system. Closed [mechanistic, deterministic] systems also require inputs in order to offset the natural decline into a state of disorder or increasing entropy unless the necessary inputs [maintenance] are regularly made.

3.0 Applying Information system theory: Developments in both Cognitive Computing technology and human intelligence vehicle control systems.

When driving, anticipation, effective visual scanning and mental concentration skills are all interlinked to support human information processing. Information Management [IM] envelops all the sequence and features of the system of car control. Roadcraft (2013, p29, p52). Due to the development of technology, human beings are not the only ones now capable of driving vehicles. Computer

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based vehicle control systems are observing, processing information, making and implementing decisions. These latter systems are undergoing continued development. The former human techniques need further improvement. These developmental needs are not mutually exclusive. They are both required in order to handle current and reasonably foreseeable driving conditions.

This study now investigates the following vehicle control systems that use:-

i. Computer cognitive intelligence deterministic systems
ii. Human intelligence based information management systems
iii. The ongoing interrelationship and overlap between these two

4.0 Computer cognitive deterministic systems: The significant implications – long [15 year+], medium [10 year] and [0-5 year] short term.

The media use the term 'artificial intelligence' as an attention seeking 'strap-line', not as a proper definition.

Cognitive computing systems comprise Artificial Intelligence [AI] artificial neural networks, 'fuzzy logic' [FL] systems and conventional temporal logic software [CTL] technologies including generic algorithms and generic programming [GP]. AI and FL apply self-training methods and the above conventional generic software can too. These AI/FL/GP technologies are intended by many developers to encourage less of and eventually achieve the complete non-involvement of our minds in driving.

Attaining this latter state will take time and require legislation. Current UK law makes the driver responsible at all times. Bosh, (Struth, 2014) claim as long as the driver monitors what the vehicle is doing and can take over, it is already permissible.

4.1 Literature review of the Progress of Current Applied Cognitive Computing Research to driving.

Over the long term, if the latest generation of 'proof-of-concept' studies develop into fully working functional prototypes then actual system build, they will completely revolutionise the way our personal transport systems operate. Providing us with 'driverless-travel-pods' to take us from place to place.

Google (2014) has recently announced it intends to build up to 200 prototype fully autonomous 'travel pods' that appear to have no means of human intervention or control, other than pressing the start and stop button and specifying the destination. The idea 'pod' passengers are so utterly dependent

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on technology is not a comfortable one. MIRA, the UK's transport research institute is developing road vehicle cooperation systems enabling vehicles to drive in platoons and eventually self navigate round cities. (Baxendale 2014, cited by Edwards, 2014, p17). The systems could be slow in universal acceptance because there is a huge legacy of individual means of conventional personal transport available that could take a generation to replace or upgrade.

A combination of AI, FL and other cognitive computing software systems are being developed for different applications. These cognitive computing technologies do have common features. For purposes of discussion and to enable evaluation of progress in the context of driving, a somewhat synthetic distinction is now being made herein between AI and FL in particular.

4.1.1 AI [Artificial Intelligence] neural network based driving systems

Complex AI 'automatic' driving systems still require investment to research, develop and deploy. This 'time-line' is taking longer than anticipated but the rate of progress is improving. Some experts believe fully automatic cars that drive themselves through bustling city streets are two decades from becoming a reality (Bohr, 2013). An overview paper confirmed the technical feasibility of AI neural network based self-driving vehicle systems (Bertozzi, et al., 2000). Different types of neural network architectures had modelled driver-vehicle-environment behaviour with promising results with small amounts of AI network training (Lin et al., 2004).

The types of artificial neuron design, interconnecting network and weighting to cause the next neuron layer to 'fire' can be altered by the AI system designer. The self-learning is by 'pattern matching' with prior training experience. (Rao & Rao, 1995). But no conventional computer program is produced containing tangible temporal logic that can be classically 'debugged' by changing program code if the decision making temporal logic is flawed. The 'logic' is stored in the interconnecting architecture layers and training pattern of the neural network. Results so far showed brittleness of driver AI based systems with better perception methods required and improvements needed in computer science to solve the technical issues (Campbell et al., 2010).

More recently published AI neural network research in the context of driving is harder to find with significant progress being reported with AI robots functioning in other domains. Progress has been reported by avoiding earlier attempts using strict 'rule-based' approaches and in its place applying Bayesian statistical probabilities of correlations within large data sets instead. (Heaven, 2013). Recent work has created robots that are developing 'theory of mind', a sentient capability learnt around the age of 3 or 4 in a developing human brain.

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One approach uses an autobiographical memory with two parts; episodic memory for recording specific events and semantic memory that turns them into rules or knowledge. This is similar to the architecture and learning process of the human mind. (Biever, citing Dominey et al., 2013). According to Ripley (2008), in earning to drive, a human driver can recognise a changing traffic light in the time it takes for a computer to process a '100 step' computer program' citing (Fieldman (1985). Ripley postulates human intelligence is using a massively parallel synaptic architecture that has learnt the technique and stored the experience in changes of the strengths of the synaptic weighting, more than changes in the brain's neural network topology. (Ripley, 2008).

4.1.2 Fuzzy logic driving systems

Fuzzy logic appears to have made more progress providing more acceptable results, partially mimicking human driving actions (Milanes et al., 2011). Fuzzy logic controllers emulated human driving behaviour and applying inertial measurement positioning to the more complex automotive overtaking. (Milanes et al., 2012).

Miniaturisation allowed typical hardware to be located behind the rear seat and where the spare tyre would be located in the boot well (Wei et al., 2013).

Fuzzy logic works with probabilities. Whilst for the vast bulk of the time system controllers provide valid output, it can still deliver errors of omission or commission with for example:-

1) 'false positives' – vehicle stops or deviates for the wrong reasons
2) 'false negatives' – vehicle fails to stop or deviate for the right reasons

Fuzzy logic strength and weakness is in the application of these probabilities. Conceptually this system performance problem can be outlined by a brief explanation, then a concept diagram, both followed by an illustrative case study.

The example below conceptually illustrates the possibility at an instant in time of a particular input data point that happens to be located in a small region where three output results are potentially possible, only one of which is the valid solution. For simplicity, a triangular probability distribution is shown.

The exact shape, hence mathematic equation for its curve thus its properties and overlapping proximity of the 'probability distributions' within the inference engine and method of working out the weighted average, can be altered as part of the development process.

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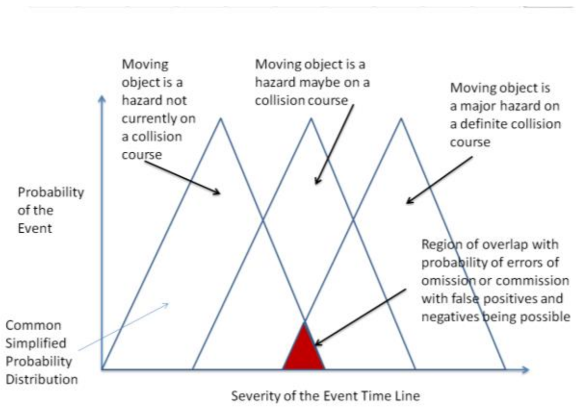
With fuzzy-logic [FL], various mathematical techniques are applied to work out a ‘weighted average’ result from imprecise or changing different sensor inputs into the ‘inference’ engine. The selected ‘region’ to derive the ‘weighted answer’ is made up of the common overlapping regions of the probability distributions in which the ‘data point’ falls.

Fig 1

Fuzzy Logic Probability Concept Diagram



Adapted from http://www.seattlerobotics.org/encoder/mar98/fuz/flindex.html. Published: in Encoder, the Newsletter of the Seattle Robotics Society. Author: Kaehler, Steven. D. Retrieved 3rd July 2014. And also ‘Neural Networks & Fuzzy Logic’ by Rao & Rao. 2nd Ed. 1995.

The inference engine derives a clear output action. The system’s sensors monitor the implementation, thus initiate on-going corrective action as the situation changes. This does not mean the system is always inherently stable, in a valid state or taking suitable action. The objective is to make it so. Even though the output reliability is being improved significantly by the empirically evolving learning or training process, a small probability of decision making error is still inherently possible.

4.1.3 Generic Programming and Electronic Microsystems

Generic programming [GP] with ‘self-building’, repairing and learning capabilities may well eventually provide a further part of the answer. Specify the ‘rules’ and provide some initial ‘best guesses’ of suitable algorithms and let the generic program derive its own improved solution, with ‘survival of the fittest’ for each iterative development cycle. This technique will grow in power and capability as computing power is increased. The ‘rules’ aka the Highway

Code, Roadcraft, et al, are well defined. The GP needs to learn how to develop, operate, repair and upgrade the control systems to apply them.

Other researchers believe the future micro systems will consist of integrated smart systems which are able to diagnose a situation, to describe and to qualify it. They will be able to identify and mutually address each other. They will be predictive and therefore they will be able to decide and help to decide. Smart systems will enable the automobile to interact with the environment; they will perform multiple tasks and assist a variety of activities. (' Preface', Valldorf and Gessner, 2006).

Autonomous driving systems will continue to develop becoming less reactive and more and more predictive. But can cognitive computing technology become really fully sentient, 'intuitively proactive' with the judgement faculty of an expert human being to fully deal with all current and foreseeable driving circumstances? If they can be built, what are the problems and implications?

4.1.4 Discussion about Cognitive Computing driving technology

In order to investigate the above questions thus study and indentify the related issues about handling uncertain future events that are yet to happen, the use of scenarios is a legitimate investigative tool. Consider the following scenario of typical driving conditions involving a fuzzy logic driving system:-

In a 50 m.p.h. speed limit, a fuzzy-logic driven vehicle is analysing the road traffic conditions whilst travelling on the opposite carriageway of a two lane road. It is coming towards your own correctly human driven vehicle. The fuzzy-logic vehicle system realises it needs to either speed up or slow down whilst you pass by, to safely overtake some parked vehicles on its near side. The system training bias is towards making journey progress. This requires it moving out partially onto your side of the carriageway and straddling the long-chain hazard centreline. The fuzzy-logic control system decides it is not on a collision course with your car. It has taken appropriate action to calculate it can move out, accelerate and move back onto its side of the road. This is in the time and distance available, dictated by the speed limit, road traffic conditions, its capabilities and the velocity of your approaching vehicle. Its fuzzy logic is working properly as expected. It commences the overtaking manoeuvre and starts overtaking the parked vehicles.

Suddenly the situation changes due to fuzzy logic sensors detecting a child running out between the parked vehicles. The child trips in fear, stumbling into its intended path. The child was hidden from its system sensors behind a parked

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white van. The child had been loitering but not moving, well out of view of its system sensors, for some while. The child had been attracted by noticing a friend standing across the road. The fuzzy logic system vehicle has now two moving objects to avoid and a choice to make. The fuzzy logic driven vehicle could swerve wider fully on to your side of the road to miss the child but move straight into your oncoming path. The distance between the vehicles would then be diminishing rapidly. It cannot stop in time to avoid hitting the child without this large deviation into your path.

As an expert human driver using good observation and anticipation skills you could have already reacted proactively. You sense intuitively the increased potential danger ahead in this scenario and already are slowing down significantly well in advance. This is even before initial movement of the child, to avoid conflict with the oncoming fuzzy logic vehicle or avoid coming in contact with the child. All this could be before the oncoming fuzzy logic vehicle system had even started to take avoiding action. The paradox is by slowing down you are actually encouraging the fuzzy-logic system vehicle to overtake the row of parked cars. Would it ‘know’ it should ‘hold-back’, avoid overtaking and significantly slow down or stop instead until you have passed it?

What has the fuzzy-logic system to do and best decision to make? It can only react very quickly in its ‘thinking-time’ to the incoming data from the sensor systems as it detected the child stumbled out into its path. It would invoke the [antilock braking system] ABS/TCS [traction control] emergency braking and steering systems more quickly than the human driver. This is because its data ‘scanning-rate’ frequency and information processing is so rapid. But the ‘stopping distance’ kinetic energy that must be converted into heat or maybe stored electrical energy by the braking / regeneration system and steer the car away from the danger with ABS/TCS invoked would be about the same no matter what system was driving the car.

Indeed it is arguable if there was a skilled human driver in the oncoming vehicle having already slowed down by being proactive, could avoid the ABS/TCS from being invoked. The entire available tyre grip would be applied stopping in a straight line with the car in its most stable condition and stopping the most rapidly. Compare this with reducing the tyre braking capacity by devoting some of the total tyre grip available into steering grip when braking and steering at the same time with ABS/TCS invoked. This compromises braking grip and potentially takes longer to stop. These advanced systems sense actual traction available in the ‘braking distance’ period, continuously distributing and altering braking and steering forces between the most appropriate wheels. Invoking these advanced traction control systems [ABS/TCS] is recognised as a sign of

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poor driving observation and anticipation in a human driver. The same judgement criteria apply with cognitive computing systems too.

This scenario is not claiming the fuzzy-logic has malfunctioned. Or that it failed to behave as trained within its ‘thinking and reaction time’. Or the vehicle’s behaviour was beyond the boundary line of the maximum safe operating envelope in any of the ‘braking-steering’ period events described above. This is not the core issue.

If the fuzzy-logic system had to choose, could it select to avoid the child but then hit you? Your vehicle has much more mass and velocity than the child hence more kinetic energy. Therefore determining it as the most dangerous to impact with, it would diagnose this as the object to avoid. Would it correctly ‘detect’ the stumbling moving object as a child incapable of getting out of its way? There is a moral judgement here that presently no artificial intelligence, only sentient human being could make, thus be considered fully proactive. At a 40 m.p.h or more impact, a child would almost certainly be severely injured or killed. A modern car with its airbags and energy absorbing safety structures mean you could survive, being merely severely shaken-up or perhaps badly bruised by the collision experience with the fuzzy logic vehicle. A human being is sentient, could make that moral choice of missing the child, not the vehicle or be expert enough to avoid both.

This continuous cognitive computing technology decision making process will always be faster than the human mind can achieve but the retarding, centripetal and acceleration forces exerted round the centre of gravity of the vehicle as ‘action’ decisions are implemented will be similar to those generated by the actions of a human driver.

4.1.5 Unpredictable driving conditions and more complex requirements

Movement of innocent objects such as low flying birds, a football or a dense batch of wind-blown autumn leaves across the road or failure to ‘read’ a 20mph flashing school sign and its speed restriction ‘end’ roundel due to wind-blown tree foliage movement, would cause similar decision making error problems. Parallel processing of corroborative input evidence from the different independent sensor systems help avoid such errors but such cognitive computing systems cannot be considered absolutely ‘fail-safe’.

Such complex automatic or semi automatic cognitive computing systems will need to be carefully maintained, with arguably ‘hard-wired’ microchip computer systems kept to aircraft levels of certification. A faulty service-pack upgrade or successful denial-of-service virus attack would be a major risk for

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any conventional system. Service pack wireless download updates would only be enabled when the vehicle was in a safe condition to do so. Very robust conventional software systems can be designed and built. It takes more time, needs trained resources and costs money to achieve it. This is not normal practice for commercial software. Thus very much higher standards of software quality must be applied if aircraft grade ‘hard-wired’ technologies are not used.

It is arguable that at present fuzzy logic systems are still not as capable of dealing with the ‘unexpected’ or ‘unusual’ compared with that of a reasonably well trained attentive driver. The problem of the human driver being inattentive in the above scenario or even ‘looking’ but not ‘seeing’ effectively is considered and solutions are tabled in further research (Westlake, 2015, ‘in draft’).

4.1.6 The weakness in the above analysis

The weakness of the above analysis is its reliance on information in the public domain. It is not clear from published research how the motor manufacturers are currently applying these different techniques to build automotive cognitive computing systems. The motor manufacturers are keeping this detailed architectural knowledge of ‘how’ these ‘self-driving systems are constructed, ‘in-house’. It is very proprietary. Research and development is considered highly valuable if it can be brought to market in fully functional systems ahead of the competition. The true full extent to which Google is already applying AI and/or fuzzy-logic vehicle driving systems is not yet in the public domain. The R & D know-how grows in significance, the more it is applied. The cognitive computing system design details need publishing for expert peer review as presently the driver is held responsible for its use. Why is this important? How robust or valid is cognitive computing driving technology?

Consider just a few illustrative issues that need to be fully understood. If the AI/ FL system is being trained by expert drivers thus only self-learning their particular pattern of behaviour, will it be able to ‘pattern-match’ and deal with the pattern of behaviour of the semi skilled, inexpert or poor driver? Will it need extensive re-training or easily handle left or right hand drive vehicles and the changeover to ‘driving on the wrong side of the road’ when UK and European vehicles ‘cross the Channel? Common sign conventions apply but will it really recognise all the ‘street furniture’, road layout architecture, road markings and signs et al of different countries, regions or districts? For example in the UK, 20m.p.h speed limit zone sign roundels tend to be very high off the ground, situated obliquely to the main road, right at the junction into the 20mph zone and may not easily be noticed. (Gilbert, 2013). Bus lane information plates and bus lane markings can be hard to read quickly enough to take action, or

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covered from view by vehicle traffic. A human driver could decide to avoid using bus-lanes as a matter of policy, until absolutely sure it use is permitted.

4.1.5 Empirical evidence of present progress

This does not mean however, the idea of 'self-driving vehicles' is just a concept or only has been built in a research lab or applied on a test track. Such functional prototypes have been operating for some while at various research centres. Test runs and competitive trials on the public highway have been made. Practical evidence is already available that the technology is in an advanced stage of prototype development within the body of a normal looking car.

BMW (2013) have been granted dispensation by the German Government to research and develop the 'driverless' vehicle, operating such a car on the public roads, provided a test driver is at the wheel who could take over control if required. The UK government is granting a similar limited use of autonomous driving vehicles with human driver supervision in designated cities, (Cable, 2014).

A video of the BMW 5 series car driving itself on the Munich autobahn is available from the Sunday Times 'Driving' website [Retrieved 9th June 2013].

This is a very significant step forward. BMW's Head of Research (Huber) into 'driver assistance and perception' believes the technology does not have much to beat, asserting more than 90% of accidents involve driver error. BMW claim the technology to be much safer, as highly automated driving systems never get tired, they do not get bored, and their concentration does not lapse. Malone (2013, page 7, cited Huber (2013). The various technologies use sensors and signal processing systems. A significant amount of information will be transmitted and received via several communication channels then processed within microchip based computer systems. A study reviewed the numerous current vehicle and road based intelligent transportation system [ITS] technologies, concluding their adoption will increase (Tewolde , 2012).

As automated vehicles eventually become prevalent, the problems of electronic interference, unwanted radar, ladar, infra-red, laser and camera image reflections, co-channel 'cross-talk' between vehicles using the range of electronic frequencies available and miscreants using 'beam-jammers' or scattering reflective aluminium 'chaff' foil that all could cause mayhem will need to be robustly solved. A significant amount of fault tolerant redundancy will be needed in the systems, enabling the systems to properly function, even if some of the sensors etc are out of service. The systems must robustly handle different climatic environments (sun, rain, fog, shadow, snow, mist etc) and

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rapid transitions between them (Bertozzi et al., 2000). Poorly maintained carriageways, worn out road markings, damaged or displaced road signs, potholes, vegetation, muddy grass verges in the countryside minor roads will all be a further problem. Even after recent repainting of some local road markings, this writer [DCW] still found 12 examples of poor, faulty, barely distinguishable road surface markings and signs within 12 adjoining kilometre squares in the O.S. map of his home. Such dangerous or challenging driving conditions, away from the UK's major trunk roads, are not uncommon. In wet weather or poor light the road markings are barely discernible by the human eye even if street lamps are present. Preventing similar lack of proper recognition in such circumstances with cognitive computing technology system sensors having data feedback 'drop-out' is a major technical challenge.

An added problem will be the eventual mixture of manual, semi-manual and highly automated driverless systems deployed at the same time on our roads, for an extended period of overlap. By definition, better equipped semi-automated and eventually fully automated vehicles will be behaving differently from many of the remaining manually driven vehicles. Keeping to all speed limits, not prematurely accelerating into the oncoming higher one or commencing braking after entering a lower one is just one example that comes to mind.

This mixed-system interaction has safety implications. It may provoke unexpected or detrimental responses from impulsive, poor or more thoughtless drivers in cars not so equipped. It may even intimidate or frighten a human driver if their vehicle becomes enveloped within a densely packed 'road-train' of autonomous vehicles. The 'road-train' could be travelling at a dynamically set traffic management system maximum velocity, in heavy traffic conditions on a motorway or dual carriageway trunk road. Such 'dense packing' of traffic, closely–coupled in system theory terms, would increase and potentially maximise the quantity of traffic flow and economise on fuel use. The haulage industry could welcome it. Their drivers could legally have a 'rest period' recorded on their tacho-graphs, with the autonomous 'auto-pilot' fully engaged. This would arguably help reduce congestion, noise, pollution and driver error. Each 'road-train' of heavy goods vehicles could be restricted to travelling in lane 1 but leaving 'lane access gaps' on approaching junctions on a two lane motorway or dual carriageway and be banned from lane 3 or 4, on a multi lane road. This would allow other vehicle drivers not to become enveloped by the 'road-train', or easily take the junction exit, or if directed, move onto or stop on the lane managed hard shoulder as a running lane or use in an emergency.

There is one area that 'self-driving' vehicles could be very useful, reducing pollution and improving public transport in our towns and cities. All electric or hybrid regenerative technology vehicles could be based at 'Park and Ride'

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locations. An intended passenger would select a ‘travel pod’ car, punch in the town/city centre destination at the same time reserving a parking bay with its battery charge point nearest to the required destination in the town/city centre. The car is then available to return to any out of town ‘Park and Ride’. This would personalise public transport, removing the need for heavily polluting diesel engine double -decked omnibuses that cause traffic congestion, heavy pollution and run nearly or partially empty most of the day.

The next-generation systems will become more effective, with more computer based artificial intelligence, will perform avoidance manoeuvres only when under threat and be better able to take control, avoiding collisions and integrate more with human drivers. (Gordon, 2013). As this ‘change-over’ becomes more prevalent and discernible as a ‘role-model’ by driving to the Road Traffic Acts, Highway Code and advanced Police class1 driving practice, the influence of improved driving behaviour will become widely culturally accepted as the way to drive.

Effective warning systems will be needed ensuring the fully automated vehicle comes to a safe halt or apply a protocol allowing the driver to take over if there is any system malfunction. As the driver may not have been concentrating on the road traffic conditions out of boredom, be intoxicated on drink or drugs or even be asleep, this is not as easy to achieve as it may first appear. Would the incapacitated or resting driver absolve himself from any responsibility by deliberately leaving the ‘driver’s seat’ vacant whilst the vehicle drove itself? The law needs revision to allow this.

4.2 Vienna Convention Changes

The amendment of the Vienna Convention on Road Traffic that "....a vehicle system which influences the way vehicles are driven shall not be deemed contrary to the convention……." (Iorio, 2013) is enabling more technological development. It still expects the driver to be paying proper attention at all times to the road traffic conditions. (Tobin, 2013, page 2) citing Iorio. The driver is still supposed to be responsible for the condition and behaviour of the car, even though functioning effectively as a passenger who may be sitting in the driving seat. However who is liable in the event of cognitive computing system malfunction; the manufacturer? This author emailed Ms Iorio for clarification [Personal Communication 19th Sept 2013] but has received no reply. A potential solution to this problem is discussed later in this paper.

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5.0 Interactive relationship between current semi-automatic driver-assist systems and the human driver.

Many ‘driver assist’ safety technologies are becoming available in currently manufactured vehicles. Relatively simpler invasive control systems, detecting and overriding some but not all driver error are becoming slowly more prevalent. As one example amongst several different manufacturers that are providing this sort of technology, BMW’s ConnectedDrive ™. (2013) supports various features in their 5 & 7 series including but not limited to:-

- Head up information display
- Night vision even beyond human ability and ‘line-of-sight’.
- Speed limit recognition
- Lane departure warning
- Lane change warning
- Approach control warning
- Pedestrian recognition protection system
- Lateral collision avoidance
- Park & reversing assist
- Traffic jam assist
- Speed & direction intervention control
- Attention assist

Such ‘driver assist’ systems are still relatively complex. Currently these systems will only be built into the original vehicle on bespoke customer order. Depending on equipment selection, this could cost several thousand pounds. It is too complex to retrofit. (Miller, D. 10th May 2013 Customer Service Manager, Menzies BMW, Stirling. (Personal Communication).

Because vehicle management software is involved there is a danger this current technology could be subjected to ‘denial-of-service’ or other type of virus attack leading to malfunction. Hackers can access a vehicle’s computer control system wirelessly via the diagnostics port or by ‘malware’ pre-loaded onto a CD and activated on insertion into the CD tray, (Harris and Tolbin 2013) citing the work of others (anon).

One problem is customer apprehension and apparent lack of comprehension leading to dislike, mistrust and indifference, hence reluctance to ‘buy-into’ this advanced but intrusive technology. There is some evidence customers currently do not wish to incorporate such devices at time of original build. (See the ‘Approved Used’ on-line car market web sites). Its current limitations and abilities are not well understood. Informal anecdotal evidence gathered by the

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author indicates some warning features when activated, are found intrusive and irritating. Why is this? One reason is these current systems do not engage the driver’s mind in the decision making, only in the response action required. The ‘driver-assist’ technology must develop and become more capable involving the driver much more effectively. This can be achieved by helping drivers avoid errors to start with and thus become a market driven ‘must-have’ accessory.

Already ‘Head-Up’ projection display on the inside of the windscreen of k.p.h or m.p.h by ‘plug & play’ auxiliary equipment, powered from the cigarette lighter socket is available. (GPS Speedmaster Controls, 2013). It is a very useful device. Recently sat-nav ‘head-up-on-windscreen’ information displays are now becoming available.

This type of ‘after-market’ accessory is likely to grow, particularly from the influence of enthusiastic younger drivers or drivers who believe ‘self-parking–assist’ for example could be a real help. Further information is available if configured to display it, on existing satellite navigation systems for the applicable speed limit and an audible warning if exceeding it. Existing ‘high-end’ sat-navs can be voice activated, enabling hands-free use. This is helpful when being asked to accept a change of route to overcome an extended traffic delay ahead due to road works, traffic congestion or an accident or re-route to a ‘favourite’ or ‘home’. This writer has found used wisely, such sat-navs are a safety aid, reducing fatigue and distracting route-finding stress. Used badly, they are a distractive menace.

It has already been pointed out that driver-assist safety systems taking action will result in the imposition of lateral forces due to changes in direction and velocity. These forces may be unexpected, unsettle the occupants who may not be concentrating on the road traffic conditions. Mercedes-Benz engineers have recognised this issue that could induce car sickness. Built into their latest S63 AMG Coupe ‘driver-assist’ systems are means to manage these lateral forces imposed on car occupants. The ‘Active Curve System’, ‘Stop and Go Pilot’ technology matches the speed with the vehicle in front, auto-steers to stay in lane and come to a complete stop as a ‘robotic driver’. (Rufford, 2014).

6.0 Complacency and other problematical trends induced by semi and fully autonomous driving systems

Is there a danger such technological trends may encourage even more driver complacency? Evidence suggested drivers’ trade off enhanced safety for speedier trips. (Winston, et al., 2006, ‘Abstract’). Research confirms system design must strike a balance between overload of attention and maintaining active involvement of the driver in the driving task. (Davis, et al., 1998).

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Unfortunately, motor manufacturers have not heeded this advice, building ‘in-car’ multi-media and voice activated mobile-office applications into cars. These utilities are not helping avoid driver distraction with research claims that voice activated communication systems are the most distracting. (Hecht, 2013, page 24 citing the work of Strayer, 2013).

A study about distracted driving among novice and experienced drivers has been recently completed. Distractions include reaching for a cell-phone or other object, prolonged study of a roadside object, texting or editing which require drivers to look away from the road. They significantly increased the risk of an accident, particularly in novice drivers. (Klauer, et al., 2014).

Google’s ‘Glass’, their wearable IM glasses currently under development, can display ‘sat-nav’ type information, within the peripheral field of vision. The glasses can also handle games, web surfing, emails, watch videos etc. (Google Glass, 2013, retrived 10th January 2014). If this device is misused, it is likely to cause some distraction to drivers. Young, novice and inexperienced drivers may not be aware of the dangers inherent in the use of this device or choose to ignore them. Even experienced but inexpert drivers may be tempted to use them improperly. A recent study has shown improvements in vehicle design, use of seatbelts and child seats have contributed to the reduction in road deaths over the last 50 years. (Fogarty, 2013). This may have reached a peak of improvement and may decline due to the ‘in-car’ distractions tabled above.

7.0 Initial Evaluation and interim conclusions– the need to take action now

Taken in aggregate, the above evidence is not showing a satisfactory overall trend in driver behaviour. Paradoxically it has been brought about as a result of vehicle systems technology becoming more safety orientated and providing more and more invasive ‘driver-support’.

8.0 Research methodology – applying information system theory

Important IM and system design constructs are found missing in the LR and need properly defining/constructing by the application of system theory. An effective architecture defining the required ‘Driving – IM’ taxonomy was found lacking. Nor was there found available a satisfactory concept Human intelligence [HI] based IM system definition diagram, a cognitive computing [CC] system development pathway or the final ‘deliverable’ performance objectives for any HI-CC system. The research methodology is now focused on such development and provides these necessary IM/IS constructs.

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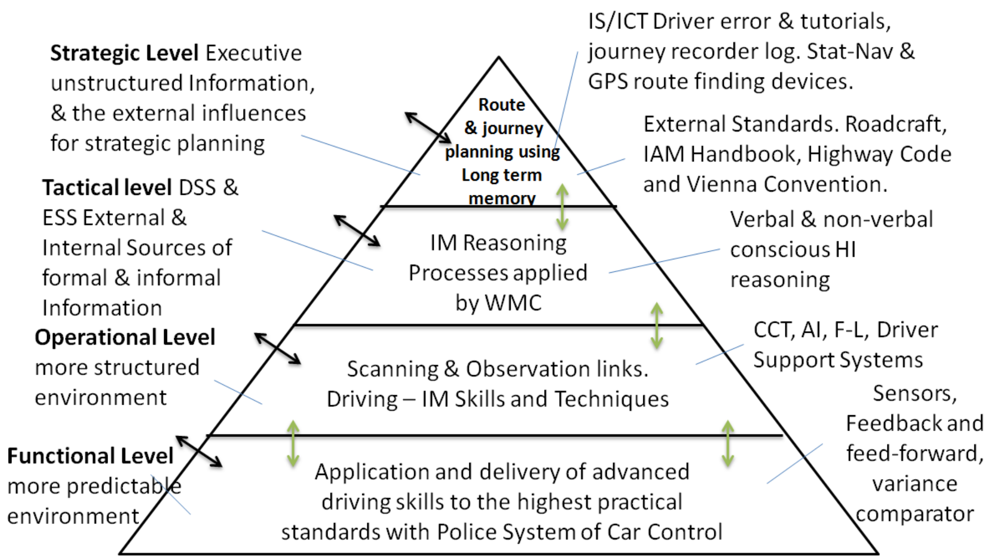
8.1 Driving – Information Management Taxonomy

Driving information management and its related systems, techniques and technologies need a more up to date architecture classification that recognises all the different but interrelated parts and roles. The diagram below is created from the study evidence, the GDE Matrix (Roadcraft 2013) and Anthoney's (1965) Taxonomy to create the Driving – IM taxonomy. It provides a classification of common features that allow and support improved reasoning methods, observation skills and techniques producing a system synergy. They are techniques, skills and system integration that include cognitive computing technology that could be further developed and applied to produce safe and effective drives in all foreseeable driving conditions in the medium and long term. [see 11.1].

A system boundary can be designated at any required level of granularity to study data and information flows across it, within it and outside it. For example the vehicle body or human driver could be arbitrarily selected for study purposes to develop a driving IM taxonomy and information processing system concept diagram. The driver is used as the system boundary below. Illustrative information flows are shown. The taxonomy identifies the information management [IM] hierarchy as driving requires effective IM at the strategic, tactical and operational level Westlake, (2015), 'in draft'. The detailed system components are omitted for clarity. They are defined Fig 5 in the more appropriate type of diagram. [See glossary of terms as required].

Fig 3

Driving – An Information Management Taxonomy



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With acknowledgments to Anthony (1965) and the later addition Davis (1974). Anthony viewed all the parts of his management taxonomy significantly linked together for management control purposes.

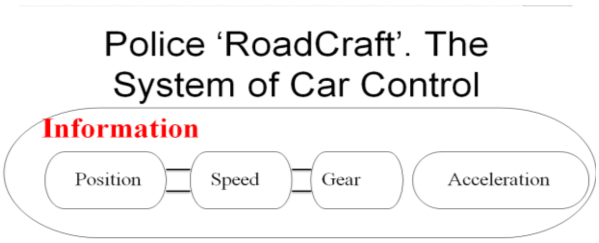
Source: Adapted from Wysocki. & Young, J; (1990). P 30-32. Roadcraft (2013, Appendix, 'GDE Matrix' – Goals for Driver education).

Management control is achieved by setting up and maintaining relevant effective communication channels between all the system parts. (Westlake, (2015), 'in draft').

8.2 Driving Information Management: How is it achieved by experts?

Information is at the very core of the 'System of Car Control' prescribed in Roadcraft, the Police Drivers Manual that has undergone regular changes and revisions by a panel of leading experts. The 2007 edition was updated in August 2013. Roadcraft (2007) page 48 indicates very clearly that becoming a better driver is related to achieving better information management.

Fig 4



The diagram is adapted from Roadcraft Chapter3 page 48, (2007).

Managing information is central to the system. Information processing runs through and feeds into all the phases, making the case that drivers should develop competence at assessing the continuous flow of information. Roadcraft (2013) page 26.This is the open system's external standard or system performance comparator. Some human based drivers have performance issues, compared with experts who apply the above system. (Westlake, 2015) 'in draft'.

9.0 HI – Driving Information Management System Conept Diagram

Information processing systems require various components. Typically an external comparator standard, sensors, data inut and information output flows across the system boundary, into a process kept under control by feedback or feedforward loops and inputs/outputs into and out of data stores. The system parts are appropriately connected together by communication channels or links

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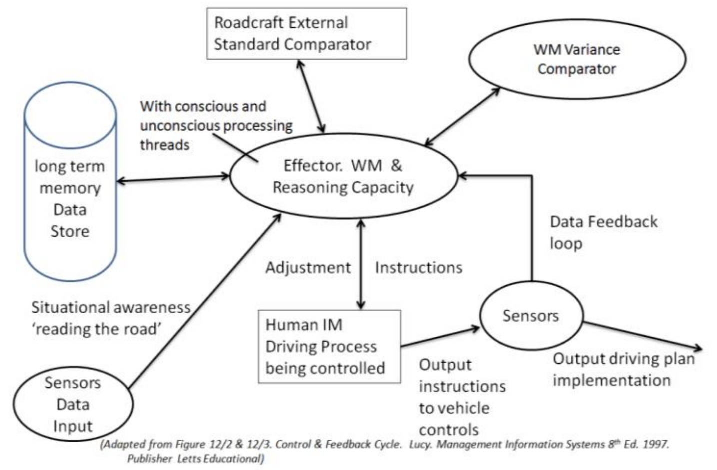
to achieve the desired performance or functionality. In system theory terms the amount of interconnection can be minimised or increased in number until they are maximised. If the system parts are ‘closely-coupled’ even with a small number of parts the number communication channels grow significantly and need maintenance. Having all the pathways means if one fails the signal will still get delivered thus provide robust system redundancy. These systems are inherently complex, costly to build, costly to maintain and tend to be inflexible.

Sufficient evidence is available to table a concept drawing of a human based driving information managment system to facilitate further study of how human capability and mixed congnitive computing-human intelligence systems should be developed.Arguably to reduce costs & encourage adaptability the intricacy of the systems should be kept to a minimum. But many extra commication links will be required to ensure robust system redundancy. A difficult combination.

Fig 5

HI Driving Information Management System



Adapted from Lucey (1997). P 154-155. & Westlake, (2015) ‘in draft’.

Communication theory was developed by (Shannon, 1948) leading to further R & D and the huge growth in information communication technology systems. Information is the meaningful content of a message. It is encoded using a system of symbols, transmitted via a channel, and decoded again on receipt. The quality of the transmission can be degraded by many reasons, making the message content eventually indecipherable. The full meaning intended by the sender needs to be fully comprehended by the receiver rapidly enough when driving to handle the prevailing driving conditions. Thus the transmission’s

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integrity, quantity and quality is vital in conveying the complexity of the message content in all its varied forms.

9.1 Our working memory: Different forms of data processed into Information.

There are interrelated means by which our minds receive 'data input'. These are visual observation, sensing movement / vibration and concurrent verbalisation. This data is then processed into information and an 'output' decision implemented, executing and updating a 'driving plan'. In system theory effective communication channels are being activated and maintained especially by concurrent verbalisation to receive data from across the system boundary (Fig 7) and to process this external data into meaningful information. (Westlake, (2015).

9.2 Maintaining the most effective communication channels with concurrent verbalisation.

This author's separate research study of expert class 1 police drivers investigated three interrelated methods of driving information management.

1. No conscious thinking effort but using a fully continuously primed subconscious, NOT inattentive 'auto-pilot'.
2. Conscious non – verbal thinking [trained commentary]
3. Conscious verbal expression [trained commentary]

Its results ranked 1 as the least effective, next 2, followed by 3 as being the most effective method of implementation of information management within the police driver's system of car control. Within the use of effective driving information management, the method of concurrent verbalisation was the most actively supported setting up and maintaining the human intelligence based communication channels. The results also showed this achieved proactive, not reactive driving, he latter being related to the inattentive auto-pilot problem. (Westlake 2015).

10.0 Cognitive Computing technology & Human Intelligence processing comparison

Cognitive computing information management systems can use adaptable massively parcelled architectures with parallel processing into a decision making interface. Or they can have several load-balanced microchips; the central processing units [CPU] working in series. The threads or processes are 'time-sliced' though the CPUs according to priority. Hence the cognitive

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computing system needs to know what is important and its rank order significance through training. The 'clock-speed' of the microchips is very fast. Cognitive computing can have a combination of parallel and series processing architectures. These architectures provide the semi-illusion of large amounts of concurrent information processing. It is augmentable as required. It is not yet fully trained to carry out all the driving tasks and process to a fully competent level.

Compare this with human information processing. The brain's architecture is still not fully understood but it takes a long time to develop and train. Its strength in thinking terms is it's highly flexible, adaptable, very intuitive and sentient too. But weakness is that it is finite, what we are individually 'blessed-with' and somewhat brittle in its information management abilities. To err is to be human, be fallible, make errors but learn and develop from the experience. Maintaining 100% concentration all the time on a single task for a prolonged period of time is completely beyond us. Arguably by better design and application of cognitive computing driving systems our human weaknesses can be adequately addressed.

11.0 Development of Cognitive Computing technology driving systems

New techniques will be required which themselves need further research and development to design and build the cognitive computing driving technologies required. As fallible human beings are involved in constructing the software and making the physical parts, such complex autonomous driving systems will still not be 100% reliable. The systems could be fully automatic but not intelligent in the human sense. Arguably they could operate at constantly better standards of performance than the bad, poor or even average driver. (Westlake, 2015), thus reduce accidents and injury. They would not be utterly 'fail-safe', still not deal with all reasonably foreseeable driving conditions and still capable of decision making error. A further 'step-change' in cognitive computing technology, becoming sentient, may improve matters but this is not without its problems that are discussed next.

11.1 CC – Driving Information Management, applying its 'Turing Test'

How will we know if and when a fully competent sentient cognitive computing driven vehicle system has been built? Systems that are as complex as this are legitimately built by a development process called evolutionary design. At each iterative design cycle the weaker parts are indentified, dropped or redeveloped and stronger parts retained, until a robust system is built. The typical 'spiral model' (Boehm, 1988) or 'double - V' model used by a leading motor manufacturer (Edwards, 2014), shows the rigorous and evolutionary approach

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to system and software development. This latter method is particularly useful when the problem cannot be properly defined at the start and may mean developing new Information Management and system build techniques that have not been done before by the system development team. They continuously learn more and more about the problem.

The evolutionary method is oriented towards SOFT [flexible and adaptable] system development methodologies that are more process rather than data driven. The alternative HARD [rigorous structured] methods solve data handling problems within existing physical systems. There are numerous methodologies to choose from already. But they are apparently inadequate, being unable to achieve ISO 26262 validation requirements within a reasonable time (Edwards, 2014). An enhanced combination of hard and soft methodologies applied in an improved robustly certified CASE [computer aided software engineering tool using a defined sequence of steps/sub system integration stages that are derived from the system development lifecycle [SDLC] may prove suitable. How do we know when the cognitive computing design objectives have been met by the SDLC? Without deliverable objectives being defined adequately, prototyping could continue indefinitely and fully functional robust operational systems never introduced.

Turing (1950, p 433), developed his famous 'intelligent test', proposing that a computing-machine could be considered intelligent if it was indistinguishable from a human being in answering questions in a game. Whilst some may disagree, arguably the same criteria could still be applied, but it needs adaptation to Driving cognitive computing.

The combined human intelligence – sentient cognitive computing technology system will need a better HCI [human computer interface], monitoring technology, improved capability and patterns of behaviour indistinguishable from that of an expert human driver [see also further work (Westlake, 2015) for the full justification for all the following features] viz:-

a) **with human driving**, applying a cognitive computing system with 'heads-up' on windscreen information display, fully equipped human eye gaze tracking and body state condition monitoring, verifying the human driver is fully cognitively engaged with the driving task. Ensuring by providing an audible supporting instruction driving plan commentary, the information processing and the driving plan being actually implemented by human intelligence conforms ideally to the Police System of Car Control (Roadcraft, 2013) requirements with the cognitive computing system monitoring and verification. The cognitive computing system

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needs to cognitively understand any human commentary, verify the driving plan and ten act accordingly by intervening as per 11.2.

b) **with CC driving**, a pattern of behaviour with full situational awareness and information processing so that its driving plan implementation performance is completely indistinguishable from a class 1 Police Driving Instructor. The best of the best with expert instruction driving decision making commentary fully available, enabled as desired and driving as per 11.2. (*With full acknowledgement to Turing. A.M, 1950*).

The above level of sentient cognitive computing driving capability should be capable of dealing with all reasonably foreseeable road traffic driving conditions, being able to operate at a much higher standard of consistent performance than the average human driver (Westlake, 2015). Logic suggests this is bound to reduce driving accidents and injury. This may appear to be the solution to poor or dangerous human driving. This does not mean such sentient autonomous systems will become perfectly reliable in all driving circumstances and utterly 'fail-safe' thus remove the necessity for satisfactory safeguards. [See 11.2 & 13.0].

Being sentient itself the cognitive computing will also detect inconsistent application of the road traffic laws, speed limits and the latest Highway Code by the different law enforcement agencies and inexpert drivers across the United Kingdom. The danger is it will then evolve its own pattern of sentient cognitive computing driving behaviour. Without restraint, develop its own interpretation of these standards and become 'non-conforming' and potentially a bigger problem than it is supposed to solve by evolving into a significant number of 'self-adapting' systems that become ultra vires. It may not respect or decide not to conform to our 'inferior' human defined codes of behaviour. The cycle of system development and its control will still be required in order to eradicate at annual MOT checks any sentient AI cognitive computing driving systems that start making 'value judgements' we humans find unacceptable.

11.2 Progressive development of functional requirements

This study has identified several important functional requirements for human intelligence driving, driver-assist and more advanced cognitive computing [CC] – human intelligence [HI] self driving systems viz:-

i) An effective external standard system comparator
ii) Human driver is expected to take over vehicle control if the CC-HI system malfunctions or cannot handle an unusual situation

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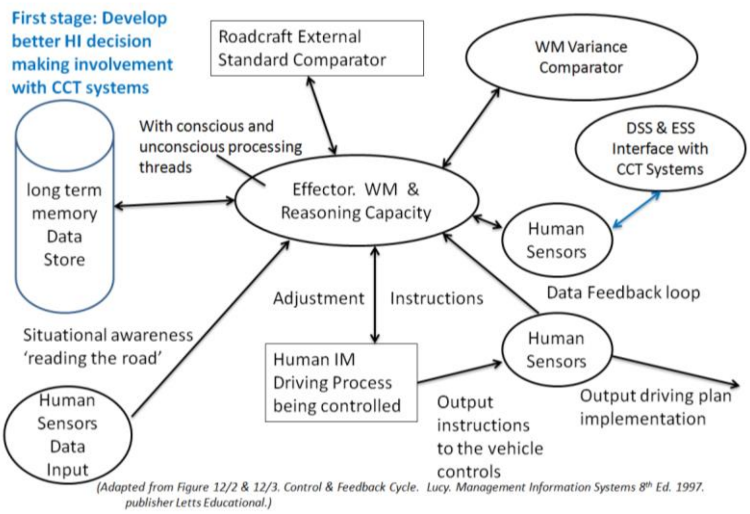
iii) Expert DSS driver-assist and more advanced CC-HI systems need to actively involve the driver's mind in decision making
iv) Commentary instructions/advice/action by the CC systems can provide the necessary feedback for i), ii) and thus solve iii) above.

The development pathway as cognitive computing driving technology is improved and developed by evolutionary system is conceptually illustrated in figures 6 to 9 inclusive below. It will take time to progress through these stages of development. The fig 8 and fig 9 level of system performance assumes the functional capability described in 11.1 has been achieved.

Fig 6

HI & CC Information Management- Improve Driver Involvement (1)



The objective is 'Driver Assist' cognitive computing that fully augments and involves the HI based IM with the latter still as the final decision maker. The present ABS / TCS systems override both when all else fails as system of last resort, with either human intelligence- cognitive computing system error. This is per figure 6 above. Note the cognitive computing sensor input and output systems and existing ABS /TCS are not shown for clarity.

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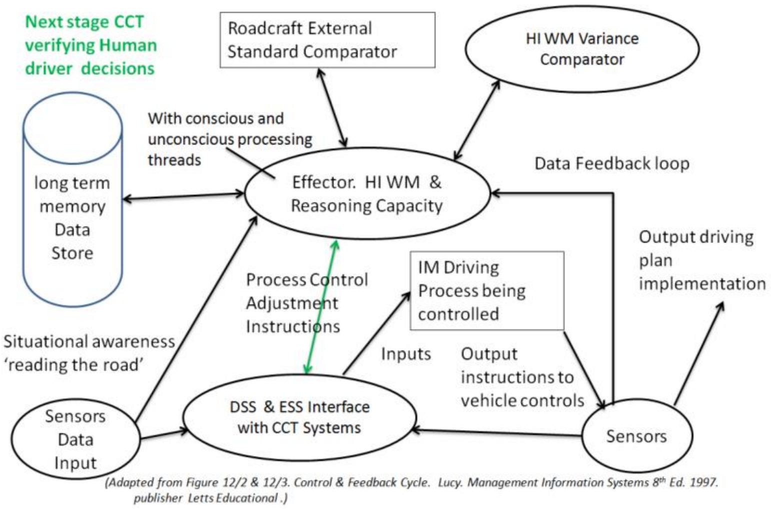
Fig 7

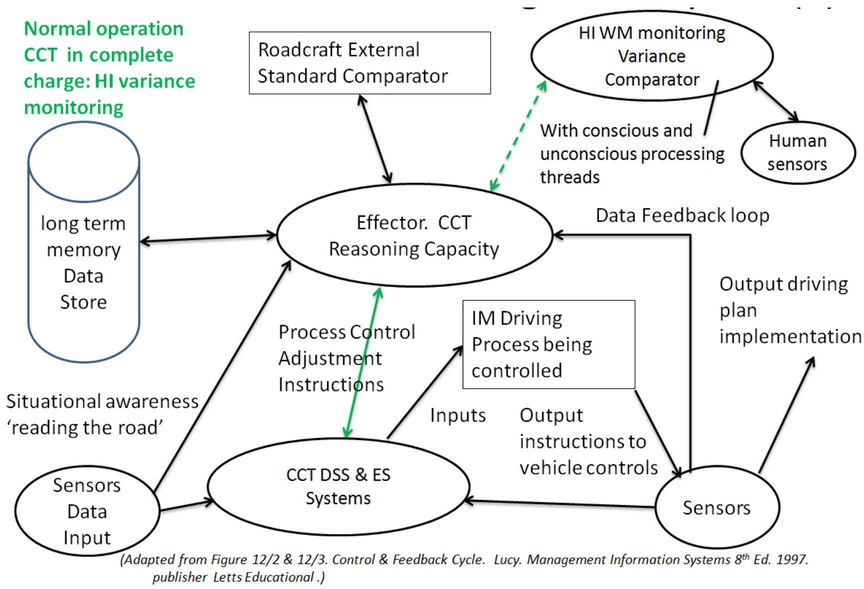
HI & CC Information Management- CC Verification (2)



As cognitive computing is progressively developed the HI decision making can be more and more 'finally verified' by the cognitive computing, before controlling instructions are input to the IM driving control process. Then the need for 'final resort' ABS/TCS being invoked should become very unlikely due to error by the human intelligence and cognitive computing systems.

Fig 8

HI & CC Information Management - CC Control (3)



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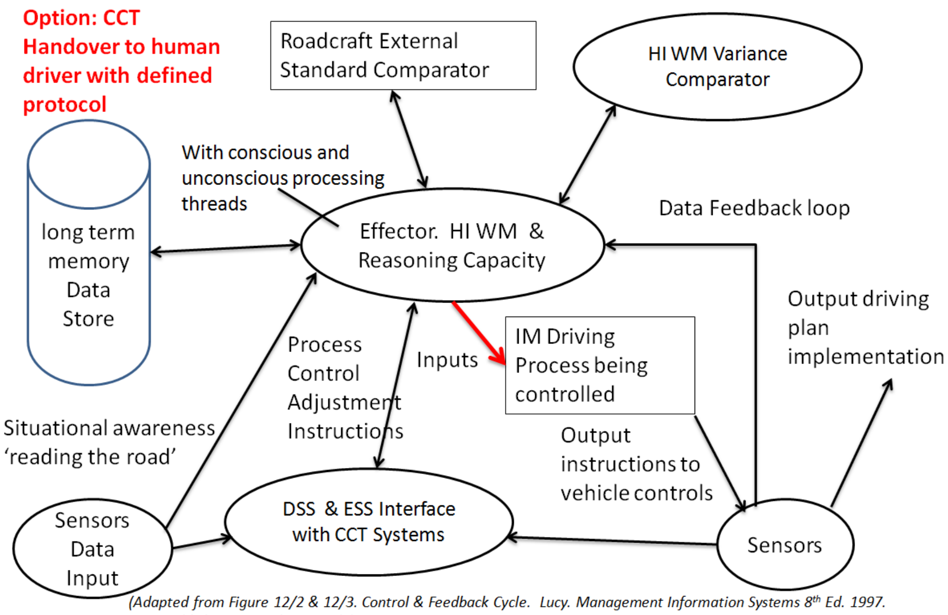
The final fig 8 & 9 stage would be when fully robust and completely developed over circa the next 20 years, the cognitive computing could fully autonomously drive the vehicle as shown above. This situation is not fully satisfactory as normally the human driver should have discretion when to take back full control intentionally or in an emergency. However if the cognitive computing is monitoring a 'manually' controlled drive and detects dangerous or repeatedly bad error prone human intelligence driving patterns of behaviour, it will issue commentary warnings, explaining the errors. If the warnings are consistently ignored or poor driving pattern not altered, it would warn, then take over control of the vehicle bringing it to a safe stop at the next suitable point such as a motorway services or parking lay-by. To continue the journey without this delay or diversion from the intended route, the driver could issue an audible instruction for the cognitive computing system to continue the drive to the destination required. The cognitive computing system would give a commentary of its reasoning.

Cognitive computing use could be the 'default' situation with human intelligence based driving being selected by the driver as required. This is analogous to normally using an automatic gearbox but taking over manual operation using the gear-shift system / steering wheel paddles available now.

Fig 9

HI & CC Information Management – HI takes over Control (4)



(Adapted from Figure 12/2 & 12/3. Control & Feedback Cycle. Lucy. Management Information Systems 8th Ed. 1997. publisher Letts Educational.)

As per figure 9 above, the human driver would at their option, still able to fully take over vehicle control and then hand back control to the cognitive computing

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with a defined handover protocol. The ABS/TCS 'final resort' systems are still not shown for clarity. This is subject to the caveat of good patterns of human driver behaviour being shown as per fig 8 on the previous page. It should be able to listen to any human driver commentary and evaluate the ongoing driving plan and proactively act accordingly to assist the driver as required.

All the above stages of development should progressively incorporate the ability to give a commentary to the driver to aid involving the driver's mind in decision making and actively monitor notice is being taken of this information.

When or if it is eventually fully developed new issues may immerge. It may need adjustment, by initial 'de-tuning' to avoid operating at the 'limits of the envelope' and not intimidate or annoy human drivers. If it is 'tuned-down' too much from the maximum level it may then be perceived as too slow and cautious, again annoying human drivers. Both the human and cognitive computing driving systems when or if the latter becomes sentient will need and be able to adapt and adopt the higher driving standards.

12.0 Some Professional Engineers and Scientists views on the development of driver-assist and more advanced cognitive computing technology systems

The Institution of Mechanical Engineers (2014) Professional Engineering Journal conducted a survey of over 500 members who answered 8 questions about the introduction of semi-automatic and automatic car driving systems with the following results:-

76% did not want 'autonomous parking' systems, only 20% said yes. Semi-autonomous systems for motorway driving obtained more support at58% but 32% did not like it. 'Head-up' information display was supported by 55%, but 45% did not or had no opinion. For many respondents, 56%, 'fully autonomous' vehicles were viewed as a total abstraction of driver responsibility with cars being supposed to be driven and thus were uncomfortable with the idea.

Devlin, H; citing Hawking (2014) who argues 'smart algorithms' are proving useful but fears the threatening consequence of general AI to the human race. Thus Hawking is against the development of sentient AI systems that would threaten us because our rate of evolution is slower than AI. A sober warning about where AI might lead. As explained above in this paper, care is therefore required in development and deployment of autonomous cognitive computing driving systems.

This is in order to not supersede or supplant human intelligence driving but aid human intelligence achieve a sound driving experience, support good driving

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habits, improve driver training at all ages and not remove the need for driving skills or allow driver skills to atrophy. A current USA NTSB hearing is investigating a crash at San Francisco Airport, asking if automated systems are leading to a decline in pilot flying skills. (Reuters News Agency report 10th December 2013). [Retrived electronically, 18th December 2013].

12.0 Summary, Conclusions & Recommendations for Future Work

There is a common thread of benefits that properly developed cognitive computing could provide by involving the driver's mind fully in formulating and implementing a satisfactory driving plan for all driving conditions.

12.1Summary

Technology is developing rapidly and more automated 'driver assist' safety systems are being built into vehicle systems. Research suggests this is currently leading to unwanted side-effects including less safety orientated or defensive driving as inexpert drivers become more complacent and further abuse the 'laws of physics'. Eventually if the current trend continues without modification, fully automated vehicles will drive on our roads. This will lead to further diminution of human based driving skills that may need to be available to take over control of the vehicle. Meanwhile urgent improvements are needed to current standards of human based driving.

Gradually more 'driver-assist', semi-automatic and eventually fully autonomous, driverless vehicles will be introduced. Systems that encourage our minds to fully engage in the driving task must be developed. [See 11.2 for a solution]. Such fully effective 'mind engaging' decision support [DSS] and expert systems [ESS] are challenging to design and build. When developed to a much better stage than currently available, such systems should help reduce the mental workload caused by multi-tasking and trying to handle the driving tasks that appear to be concurrent and may find difficult to accomplish (Cao & Liu, 2013).

Fully trained and applied well with effective cognitive computing assistance, human intelligence based driving is still arguably much better than relying on fully autonomous vehicles working entirely on their own. This may appear counter intuitive but it will maintain both our skills and evolvement in driving decision making, enabling human drivers to take over should the situation require it. This situation is analogous to that of airline pilots and their use of auto-pilot systems even though the technology, takeoff and landing systems render the pilots almost unnecessary. Pilots are available if required. It will also help resolve the situation when two or more vehicles with cognitive computing

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technology driving systems wish to occupy the same physical space at the same time thus resolve the auto-navigation ‘time-over-target’ problem.

Developments in IS/ICT now allow performance monitoring of individuals at ever finer level of granularity, thus awarding punishment and rewarding redemption for errors of judgement in a constructive and directly attributable way. The police could evaluate the in car ICT based databank ‘black-box’ record at the roadside, check if a threshold of cumulative examples of bad driving behaviour is reached. Repeated offending of a serious traffic offence nature recorded on the ‘black-box’ should incur penalty points on the UK driving licence if the Police issue a penalty notice. Fines /imprisonment etc would become limited to serious motoring offences as the monitoring system could adjust the miscreant’s direct motoring costs such as vehicle excise duty and fuel taxes, up and down. Similar monitoring of the cognitive computing system operational performance will enable system management diagnostics to be regularly made and authorised motor manufacturer adjustments completed.

12.2 Recommendations for future work

How the human intelligence - cognitive computing is combined to create a combined system that verifies, checks then intervenes, yet balances the human driver ‘needs’ and ‘wants’ requires much more research. The development will need to be in stages. The present ‘driver-assist’ systems are proving somewhat annoying and inadequate, tending to make drivers complacent. They can be improved.

More work is needed to ensure cognitive computing driving technology invokes our minds fully in decision making, encouraging better performance. It should inform us why/how our driving is not up to standard so avoiding complacency, not just making us suddenly pay more attention. Invoking verbal or non-verbal commentary [concurrent verbalisation] can solve both these problems.

13.0 Final Conclusions

Effective communication channels between combined cognitive computing – human intelligence technologies can be achieved by concurrent verbalisation. Improved quality-of-design-and-build methods are required to develop safe and robust self-drive automotive software and systems. The above prima facie evidence confirms the view according to system theory, it should be both man and machine working in harmony. Both cognitive computing and human intelligence need to suitably interact to provide security, with satisfactory operation in all driving conditions and a performance synergy. Otherwise like the warning in the CAA report (2014) that the introduction of new technology

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and further automation in the cockpit would lead to pilots being unable to retain their own flying skills sufficiently to avoid the increased risk of a 'loss of control event' when the technology malfunctions.

David Westlake

MSc; P. Dip. B.A.(Edin); C.Eng; M.I.Mech.E; M.I.E&T; M.C.M.I; F.H.C.A; M.I.A.M.

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The author reports no conflict of interest related to this work.

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