



Breakout session 1

Views on definitions of edge cases

11.5.2021



Agenda and participants

- Moderators: Sami Koskinen, VTT & Yvonne Barnard, University of Leeds
- Moderators introduce different aspects of edge cases. Telco-like discussion
 - **What do we consider as edge cases and how do we approach them?**
- Short presentation by Digitrans on their edge case highlights, after first discussion topics
- Padlet

- Please briefly present yourself the first time you speak: name, organisation, country
- Number of participants:



Edge case in dictionaries

- **An unusual or unforeseen situation where something may fail to work properly or as expected** – Oxford Dictionary
- **A problem or situation that occurs only at an extreme (maximum or minimum) operating parameter** – WordSense
- **Scenario in which the extreme values or even the very presence of one or more parameters results in a condition that challenges the capabilities of the system** – DIN SAE SPEC 91381
 - **SYNONYMS:** outlier, unusual occurrence, rarity, oddity, anomaly, abnormality, peculiarity, irregularity, inconsistency, incongruity, deviation, aberration, quirk, freak, exception, departure, divergence, variation – Oxford Dictionary
 - Wiki also gives “boundary case” as a synonym

Similar terms

- An **outlier** is an observation that lies an abnormal distance from other values in a random sample from a population. In a sense, this definition leaves it up to the analyst (or a consensus process) to decide what will be considered abnormal.
 - <https://www.itl.nist.gov/div898/handbook/prc/section1/prc16.htm>
- In engineering, a **corner case** (or **pathological case**) involves a problem or situation that occurs only outside of normal operating parameters—specifically one that manifests itself when multiple environmental variables or conditions are simultaneously at extreme levels, even though each parameter is within the specified range for that parameter.
 - https://en.wikipedia.org/wiki/Corner_case

SOTIF* Areas vs Edge Cases?



- MEASURES FOR AREA 1 – Maximize the area of safe behavior
- MEASURES FOR AREA 2 – Minimize the known potential unintended scenarios
- MEASURES FOR AREA 3 – Minimize the unknown unintended scenarios
- Whereas an edge case could be “potentially dangerous”
- * SOTIF is Safety Of The Intended Functionality — ISO/PAS 21448

Edge cases in software testing

- **In software testing, edge cases are bugs that are uncommon** for users to encounter. This doesn't always mean that it's hard to reproduce the bug. Sometimes the bug may be happening 100% of the time – but only on an iPhone model that makes up a very small share of the customer base.
 - Source: <https://www.mindfulqa.com/edge-cases/>
- An edge case is **rare situation**. Edge cases often threaten to break a system and the user experience. For example, if an application allows for “unlimited” photo uploads knowing that users rarely upload more than 1000, how does the system deal with the edge case of the user who uploads millions of photos? Are there boundaries at this maximum end? That is an edge case, an **unlikely-yet-potentially disastrous situation**.
 - Source: <https://www.uxbeginner.com/glossary/edge-case/>
- ❖ How SW testers usually find the bug: use the SW more, run test cases or test piece by piece

What is difficult for automated vehicles?

- Driving is often considered as an easy task. Still, it combines surprisingly many processes. Drivers apply skilful optimisation methods, e.g., in their trajectory planning
- The difficulties for a computer are not exactly the same as for human drivers. Humans excel at interpreting situations, whereas computers are able to monitor the environment tirelessly and measure distances accurately. Computers react faster but may not see as far.
 - Probably the main difficulty for automation is about achieving reliable environmental sensing and classification
 - Even after achieving that, understanding complex situations will still be hard
 - Liability in case of an accident, what is reasonable behaviour for road users?
- Systematically considering probabilities in every step is difficult: to conclude that
 - Positioning accuracy is too low, map is outdated
 - Object ahead is something new that has never been taught

Current or future edge cases?

- AV wouldn't give space to another driver who wishes to change lane
- AV doesn't react when the car in front needs to reverse and the driver yells out of the window
- AV doesn't recognize road worker signs or obey event parking staff
- AV stays put, when sun is shining to the camera in traffic lights
- AV drove into broken glass or a deep puddle, while no other driver did
- AV drives near a child on a bicycle

Discussion 1: ODD's edge versus edge cases

- Current prototypes require certain simplicity and environmental conditions, and are bound by their operational design domain, ODD. It's still a new term, but it seems to define typical conditions
- For example, the ODD might include light rain but not heavy rain. Therefore, the “edge case” is heavy rain, which is not... rare. Detecting the edge case would be based on a rain sensor / sensor noise etc
- The ODD and system specifications might even define that the automation only works on empty roads. Pedestrian-related edge cases are then solved...
- As the vehicles become more capable and operate in close proximity to humans, the ODD's edge moves. Level 4 ODD, level 5 ODD... They start to enter the more difficult cases.
- **Discussion: Testing ODD's edge vs testing edge cases? Is the definition of an edge case about one unique system's ODD, or about listing dangerous situations for many systems? An edge case for lidar may not be an edge case for radar, and vice versa.**

Discussion 2: How frequent and many are edge cases?

- In computer vision neural network training, different cases can be mundane but they can have an effect. Variations seem infinite: different lighting, shadows, reflections, texture. Traditionally, reliable computer vision requires controlled lighting.
- The “long tail” of cases is often mentioned, but how to grasp the total amount and meaning of edge cases? If a car cannot cope with 1% of intersection scenarios, a situation like that will come up fast
- Some of the “edge cases” seem very common when compared against accident data or fatal risk management goals. Fatalities happen 1 per a few million hours and risk management requirements have similar targets
 - Say 8 hours of a year in Finland there’s an extremely difficult snowstorm: difficult to see road edges, vehicle doesn’t turn normally. That is 8/8760 hours of the year. Is that rare, or about managing something common and expected?
- A volcano erupting in Finland, can we rule that out? A volcano in Iceland, that can happen.
- **Discussion: They seem to have very different likelihoods (and then each has to be mitigated so that the accident risk remains small)? Are they so many/different that they are extremely difficult to cover?**

Discussion 3, extreme road user behaviour as an edge?

- Do we need to mathematically prepare for suicide-level pedestrian or other road user's behaviour? Maybe not for everything, but the middle ground is difficult: sprinting child, drunken cyclist falling, an old person accidentally driving towards us on our own lane?
- Automated vehicles could prepare e.g. by setting maximum expected acceleration of a pedestrian to sprinter-level. As long as the pedestrians are further away than a couple of seconds of sprinting, driving can continue normally, otherwise the AV slows down. Wouldn't drive much slower than humans currently do, but in many situations the behaviour could seem overly careful and maybe annoying, if the AV constantly anticipates worst cases.
- In many of such cases, the AV might not be at fault. But still, when media discusses a terrible accident: what if a human would have likely spotted the running child earlier than what the AV did...?
- **Discussion: to what level should AV anticipate worst cases and try to avoid them? List "all" cases and analyse liability?**

Padlet – edge case categories

- Please open
 - <https://universityofleeds.padlet.org/ybarnard/fvy37x3mklzmkmmf>
- Everyone can write to the boxes, please do!

Discussion 4, winter is coming

- Nordic countries may not be the place to start AD operations, but similar topics come up when discussing 24/7 driverless operations in European harbours, airports and factory yards
- Many lidars start to lose data from their point clouds around -10°C and shut down at -20°C . Sensors need environmental protection, currently this is not the case.
- Accurate and continuous estimation of tyre–road friction potential remains a Nobel price level of a topic. Research vehicles can have a pointwise idea of ice/snow/water and measure tyres slipping, but they struggle to assess the road ahead for different trajectories. Drivers know the road conditions much better than their vehicles. Vehicles can compensate by driving slower.
- Tesla is able to drive a bit on snow, if one adjusts cruise control speed low. It detects road boundaries rather nicely, compared to previous work. Still, winter operations is a research topic.
- Discussion: what weather-related edge case research we know of and need?

Thank you!

- “I suspect that to get this right we will end up wanting our cars to be as intelligent as a human, in order to handle all the edge cases appropriately. And then they might not like the wage levels that ride-sharing companies will be willing to pay them.” – <https://rodneybrooks.com/edge-cases-for-self-driving-cars/>
- ARCADE may feature some of these topics in the updates of the knowledge-base and FESTA evaluation methodology handbook
- Edge cases play a role in upcoming CCAM projects
- Thank you all for the discussions!