

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TESLA, INC.,
Petitioner

v.

Intellectual Ventures II LLC.,
Patent Owner

IPR2025-00342
U.S. Patent No. 7,336,805

**Declaration of Dr. Jeffrey J. Rodriguez Under 37 C.F.R. § 1.68
In Support of Petition for *Inter Partes* Review of
U.S. Patent No. 7,336,805
(Claims 1-2 and 6-11)**

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I, Jeffrey J. Rodriguez, do hereby declare as follows:

I. INTRODUCTION

1. I have been retained by counsel for Tesla, Inc. (“Tesla”) as an independent expert witness for the above-captioned Petition for *Inter Partes* Review (“IPR”) of U.S. Patent No. 7,336,805 (“the ’805 Patent”). I am being compensated at my usual and customary rate for the time I spend in connection with this IPR. My compensation is not affected by the outcome of this IPR.

2. I have been asked to provide my opinions regarding whether claims 1-2 and 6-11 (the “Challenged Claims”) of the ’805 Patent are unpatentable as they would have been obvious to a person having ordinary skill in the art (“POSITA”) as of the earliest claimed priority date.¹

II. QUALIFICATIONS AND PROFESSIONAL EXPERIENCE

3. My current curriculum vitae is attached as Exhibit 1004, which includes a detailed listing of my education, work experience, honors, awards, professional

¹ I understand that the ’805 patent claims priority to German Patent Application DE 10 2004 028 763.5, filed June 16, 2004. I have been instructed by counsel to assume for purposes of my analysis that the earliest claimed priority date is June 16, 2004.

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associations, publications, and a list of expert consulting activities during the past five years in which I have testified as an expert at deposition or trial.

4. I am a professor at The University of Arizona in the Department of Electrical & Computer Engineering, where I hold or have held the following positions: (a) Associate Professor of Electrical & Computer Engineering, with tenure (1997–present), (b) Associate Professor of Biomedical Engineering, with tenure (2017–present), (c) Director of ECE Online Programs (2023–present), (d) Director of the Signal and Image Laboratory (1990–present), (e) Director of Image Analysis, Cancer Imaging Shared Services, Arizona Cancer Center (2009–2014), (f) Co-Director of Connection One, a National Science Foundation industry/university cooperative research center for wired and wireless communication circuits and systems, (g) Director of Graduate Studies for the Department of Electrical & Computer Engineering (2000–2003, 2005–2016).

5. My formal education includes a Bachelor of Science degree in Electrical Engineering from the University of Texas at Austin in May 1984, a Master of Science degree in Electrical Engineering from the Massachusetts Institute of Technology in June 1986, and a Ph.D. Degree in Electrical Engineering from the University of Texas at Austin in May 1990. I teach courses at both the graduate and undergraduate level through the Dept. of Electrical & Computer Engineering and the College of Optical Sciences. The courses I have taught include Digital Image

Processing, Digital Image Analysis, Digital Signal Processing, Advanced Digital Signal Processing, Signals and Systems, and Circuit Analysis. I have been awarded the Outstanding Teaching Award by the IEEE and Eta Kappa Nu (IEEE-HKN), given by students at The University of Arizona to one outstanding professor each year.

6. My research activity focuses on systems for digital signal/image/video processing and analysis. My research activities include automated detection/classification/recognition of regions/objects/targets using neural networks and other machine learning methods, as well as conventional technologies. My research has included applications such as military target recognition, biomedical image analysis, animal species classification, convolutional neural networks for driver distraction detection, and real-time video processing for analysis of zebrafish.

7. One of my recent research projects involved the design and development of a real-time image and video processing system for automated detection and behavioral analysis of zebrafish for use in ototoxicity assessment of drugs. The system we designed and built includes an array of Raspberry Pi microcomputer systems configured for parallel video capture of sixteen zebrafish populations. Each Raspberry Pi features a system on a chip, which includes a CPU, a video graphics processing unit (GPU), a disk storage system, and a memory system. Our zebrafish analysis system automatically captures and transmits

compressed MPEG video data to a local personal computer or to a high-performance computing cluster to decode the video and implement customized algorithms for detection of zebrafish pose and motion using multi-scale edge map analysis, resulting in automated assessment of zebrafish swimming behavior.

8. In a past research project, I developed a terrain matching algorithm for use in a passive aircraft navigation system based on image processing rather than using active emissions such as radar. A sequence of aerial, optical images are analyzed using stereo analysis of successive images to generate an estimated elevation map of the corresponding terrain. Next, edge detection is applied to the estimated elevation map to obtain a “cliff map” representation of the terrain surface. Similarly, edge detection is applied to a reference digital elevation map of a large geographical area to obtain a reference cliff map. Finally, the estimated cliff map is matched to the reference cliff map by performing edge segmentation, then shape analysis of the edge segments, followed by a matching algorithm to align the edge segments of the estimated cliff map with those of the reference cliff map. The position and heading of the aircraft are determined by locating the position or orientation of the recovered cliff map within the reference cliff map.

9. I am a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE) and the IEEE Signal Processing Society. I served as Treasurer of the 2024 IEEE Southwest Symposium on Image Analysis and Interpretation

(SSIAI), General Chair of SSIAI 2016, and General Chair of the 2007 IEEE International Conference on Image Processing (ICIP). In addition, I served on the IEEE Signal Processing Society Technical Committee on Image, Video, and Multidimensional Signal Processing (2005–2011) and served as Associate Editor of the IEEE Transactions on Image Processing (1996–2000). Over the years, I have served on numerous other professional committees, and I have served as a technical reviewer for numerous journals and professional conferences.

10. I am named as an inventor on a patent involving polar dynamic programming for automated image segmentation. I have authored or co-authored over 140 technical publications. Over the past 30 years, I have trained hundreds of students in signal/image/video processing, including directing the research of numerous graduate students, resulting in more than 50 graduate theses and dissertations. I have served as an expert in patent cases since 2005, involving signal/image/video processing, data compression systems, video receivers, document cameras, cellular camera phones, signal/image/video transmission over wireless networks, etc.

III. MATERIALS CONSIDERED

11. In preparing this Declaration, I have reviewed:

- Ex. 1001, the '805 Patent;
- Ex. 1002, the file history of the '805 Patent;

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- Ex. 1005, “Visual Perception of Obstacles and Vehicles for Platooning,” Broggi et al. (“Broggi”);
- Ex. 1006, “Object Recognition Using Alignment,” Daniel Huttenlocher et al. (“Huttenlocher”);
- Ex. 1007, U.S. Patent No. 5,434,927 to Brady et al. (“Brady”);
- Ex. 1008, “Automatic Vehicle Guidance: The Experience of the ARGO Autonomous Vehicle,” Alberto Broggi, Massimo Bertozzi, Alessandra Fascioli, and Gianni Conte (“Bertozzi”).
- any other document cited below.

In forming the opinions expressed in this Declaration, I have considered:

- a) the documents listed above,
- b) any additional documents and references cited in the analysis below,
- c) the relevant legal standards, including the standard for obviousness, and
- d) my knowledge and experience.

IV. LEVEL OF ORDINARY SKILL IN THE ART

12. I understand there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including (1) the levels of education and experience of persons working in the field at the time of the invention; (2) the

sophistication of the technology; (3) the types of problems encountered in the field; and (4) the prior art solutions to those problems.

13. For my analysis, I have been asked to assume that the time of the claimed invention is the filing date of the '805 patent, which is June 16, 2004.

14. A person of ordinary skill in the art at and before the claimed priority date of the '805 Patent (June 16, 2004) ("POSITA") would have had a bachelor's degree in electrical engineering, computer engineering, computer science, or a related subject, and four years of work experience in image processing, automated vehicle control/navigation, or a related field. Additional education would offset a lesser amount of experience, and vice versa.

V. LEGAL PRINCIPLES

15. I am not an attorney and offer no legal opinions. For the purpose of this Declaration, I am relying on certain basic legal principles that counsel have explained to me. These principles are discussed below, and the analysis in this Declaration is in accordance with these legal principles.

A. Prior Art

16. I understand that prior art to the '805 Patent includes patents and printed publications in the relevant art that predate the priority date of the '805 Patent. I have been instructed by counsel to assume for purposes of my analysis that the earliest claimed priority date is June 16, 2004. I have not considered and express no opinion

as to whether the claims of the '805 Patent are actually entitled to a priority date of June 16, 2004.

B. Obviousness

17. I have been informed that a claimed invention is unpatentable under 35 U.S.C. § 103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. I have also been informed by counsel that the obviousness analysis takes into account factual inquiries including the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter.

18. I have been informed by counsel that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include the following: (a) combining prior art elements according to known methods to yield predictable results; (b) simple substitution of one known element for another to obtain predictable results; (c) use of a known technique to improve a similar device (method, or product) in the same way; (d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (e) choosing from a finite number of identified, predictable solutions with a reasonable

expectation of success; and (f) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

19. I further understand that a claim would have been obvious if it unites old elements with no change to their respective functions, or alters prior art by mere substitution of one element for another known in the field and that combination yields predictable results. Also, I understand that obviousness does not require physical combination/bodily incorporation, but rather consideration of what the combined teachings would have suggested to persons of ordinary skill in the art at the time of the claimed invention. I understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.

20. As mentioned above, I understand that a claim would have been obvious if it unites old elements with no change to their respective functions or alters prior art by mere substitution of one element for another known in the field and that combination yields predictable results. While it may be helpful to identify a reason for this combination, I understand that there is no rigid requirement of finding an express teaching, suggestion, or motivation to combine within the references. When a product is available, design incentives and other market forces can prompt variations of it, either in the same field or a different one. I understand that if a

POSITA can implement a predictable variation, obviousness likely bars its patentability. For the same reason, I understand that if a technique has been used to improve one device and a POSITA would recognize that it would improve similar devices in the same way, using the technique would have been obvious. I understand that a claim would have been obvious if common sense directs one to combine multiple prior art references or add missing features to reproduce the claimed invention.

21. I further understand that certain factors may support or rebut the obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the patented invention, skepticism of those having ordinary skill in the art at the time of invention, unexpected results of the invention, any long-felt but unsolved need in the art that was satisfied by the claimed invention, the failure of others to make the claimed invention, praise of the claimed invention by those having ordinary skill in the art, and copying of the claimed invention by others in the field. I understand that there must be a nexus—a connection—between any such secondary considerations and the claimed invention. I also understand that contemporaneous and independent invention by others is a secondary consideration tending to show obviousness.

22. I am not aware of any allegations by the named inventors of the '805 Patent or any assignee of the '805 Patent that any secondary considerations tend to rebut the obviousness of the Challenged Claims of the '805 Patent.

23. I understand that in considering obviousness, it is important not to determine obviousness using the benefit of hindsight derived from the patent being considered.

C. Other Challenges to Validity

24. I understand that other challenges to the validity of a patent, including patent ineligibility, enablement, written description, and indefiniteness, cannot be raised in *inter partes* review proceedings before the Board to challenge the validity of the '805 Patent. Accordingly, I did not consider those other challenges.

D. Level of Proof

25. I understand that Petitioner has the burden of proving unpatentability by a preponderance of evidence, which means it is more likely than not that the claims are unpatentable.

E. Interpretation of Claims

26. I understand that the claims are to be construed according to the same claim construction standard that district courts use wherein claim terms are given their ordinary and customary meaning from the perspective of a person of ordinary skill in the art at the time of the invention.

VI. THE '805 PATENT

A. '805 PATENT OVERVIEW

27. I understand that the '805 Patent issued on February 26, 2008, from U.S. Patent Application No. 11/154,772 (“the '772 Application”), filed June 16, 2005, and claims priority to German Patent Application DE 10 2004 028 763.5, filed June 16, 2004. The face of the '805 Patent lists Ottmar Gehring et al. as the inventors. I have been informed by counsel that, according to assignment records, Intellectual Ventures II LLC is the current assignee of the '805 Patent.

28. The '805 patent describes a method for docking assistance using image analysis. Ex. 1001, Abstract. A vehicle is equipped with a camera (e.g., image sensor 22 on vehicle 20 as illustrated in Fig. 2 below) to obtain image data. Ex. 1001, 2:56-57.

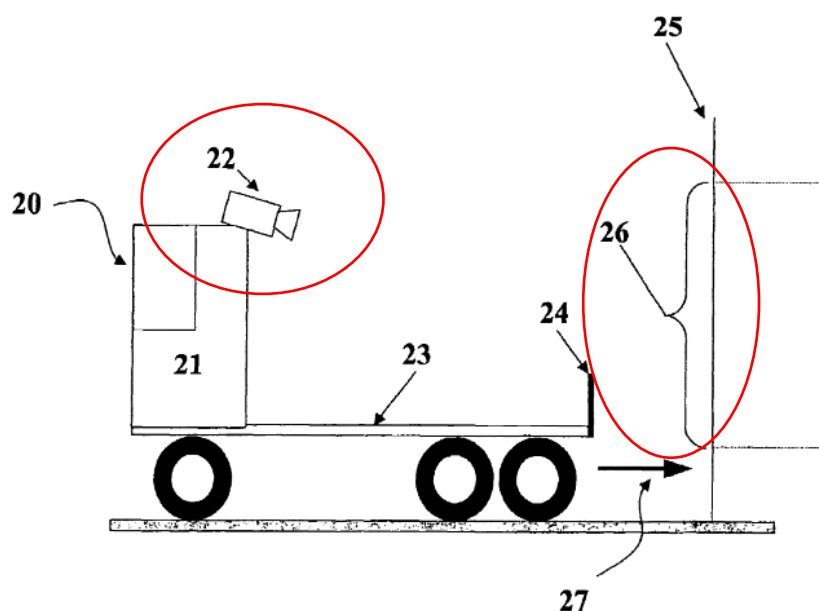


Figure 2

Ex. 1001, Fig. 2 (annotated)

29. Obtained images are analyzed to locate objects such as a cargo door 26 illustrated in Fig. 2 (above). Ex. 1001, Abstract, 7:13-29. Following common practice, the obtained image data is broken down into edge segments. Interrelationships between the edge segments are stored in a tree structure. Ex. 1001, 3:37-39; 4:43-45. The '805 patent itself recognizes that “[m]any different proven methods for creating and organizing such a hierarchical tree structure are available to one skilled in the art.” Ex. 1001, 4:45-47. The edge segments are then analyzed to check for the presence of a geometric object that is similar to a shape (e.g., geometric form) associated with a potential destination of the vehicle. Ex. 1001, 3:40-43. In this regard, the '805 patent explains that “the

typical geometric form substantially corresponds to a rectangle.” Ex. 1001, 3:45-46. The detected geometric objects are then “analyzed for plausibility” using a known matching algorithm. Ex. 1001, 2:41-43; 3:3-8; 3:47-50; 5:25-29 (The well-known “IPC [sic] algorithm ... is particularly advantageously suited.”).² Plausible objects then undergo an additional “acceptance analysis.” Ex. 1001, 3:41-54. Accepted object(s) are then used in calculating a trajectory for the vehicle to assist in vehicle guidance. Ex. 1001, 3:61-66.

30. Image processing for vehicle navigation as described in the ’805 patent was widely used before the priority date. For example, image processing techniques such as edge detection, edge segmentation, and matching algorithms were all commonplace. *See, e.g.*, Ex. 1005, 170-171 (describing vehicle detection using a “traditional pattern matching technique,” and describing the extraction of vertical and horizontal edges); *see generally* Ex. 1006 (describing “Object Recognition Using Alignment”). These techniques were also widely used in the specific context of vehicle navigation assistance. *See, e.g.*, Ex. 1005, 170-171 (describing vehicle detection for purposes of platooning). The ’805 patent describes and claims a combination of image processing and vehicle guidance techniques

² While the ’805 patent references the “IPC algorithm,” it is actually referring to the iterative closest point, or ICP, algorithm.

that were widely utilized long before the earliest claimed priority of the '805 patent.

B. '805 Patent Prosecution History

31. The U.S. Patent Application that issued as the '805 Patent (U.S. Patent Application No. 11/154,772 referred to herein as “the '772 Application”) was filed on June 16, 2005. The '772 Application claims priority to a German Patent Application DE 10 2004 028 763.5, filed June 16, 2004.

32. Even though the '805 patent described and claimed a combination of well-known elements, the examiner issued a first action allowance for all claims. Ex.1002, 26. The Notice of Allowance identified elements [1.4.0], [1.4.3], and [1.4.4] as the allowable features of independent claim 1. Ex. 1002, 31. As shown in Section VIII below, elements [1.4.0], [1.4.3], and [1.4.4] are obvious over prior art not considered by the Examiner.

C. Challenged Claims of the '805 Patent

33. I have been asked to provide my opinions regarding whether claims 1-2 and 6-11 (“the Challenged Claims”) of the '805 patent are unpatentable as they would have been obvious to a POSITA at the time of the claimed invention, in light of the prior art. For example, claim 1 is recited as follows, where reference labels [1.0], [1.1], etc. have been added to individual portions of the claim for convenience:

Claim 1. [1.0] A method for assisting guidance of a motor vehicle on the basis of image data, the method comprising:

- [1.1] acquired image data using an imaging sensor from a surrounding field of the motor vehicle;
- [1.2] extracting from the acquired image data positional parameters of at least one potential destination relative to the motor vehicle; and
- [1.3] calculating at least one trajectory describing an optimized travel path using the positional parameters so as to assist a subsequent vehicle guidance for at least one of the potential destinations,
- [1.4.0] wherein the extracting includes:
 - performing an edge detection and edge segmentation on the image data so as to break down the image data into a plurality of edge segments and storing interrelationships of the plurality of edge segments in a mathematical tree structure;
 - [1.4.1] analyzing the plurality of edge segments for the presence of a geometric object associated with a geometrical form that may at least partially describe a potential destination so as to identify one or more potential geometric objects;
 - [1.4.2] analyzing the one or more potential geometric objects for plausibility using a matching algorithm so as to identify one or more plausible objects;
 - [1.4.3] performing an additional acceptance analysis so as to identify at least one accepted object, the additional acceptance analysis including analyzing a shape of the image formation of each object in the image data based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field; and
 - [1.4.4] storing at least one accepted object that corresponds to a most proximate destination together with corresponding relative positional data in an object list.

VII. CLAIM CONSTRUCTION

34. It is my understanding that in order to properly evaluate the '805 Patent, the terms of the claims must first be interpreted. It is my understanding that the claims are to be construed according to the same claim construction standard that district courts use. Under the claim construction standard that district courts use (i.e., the so-called *Phillips* standard), claim terms are given their ordinary and customary meaning from the perspective of a POSITA at the time of the invention. I have been

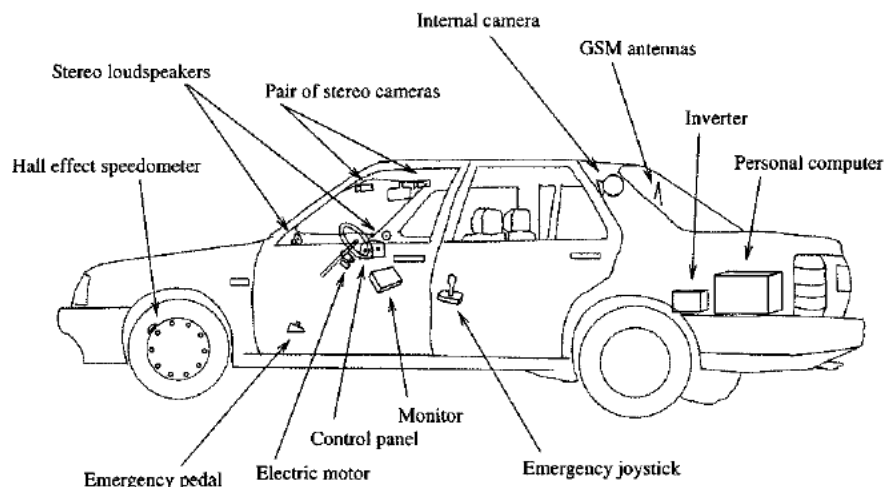
informed that that the phrase “ordinary and customary meaning” in the so-called *Phillips* standard is often referred to as the “plain and ordinary meaning.” I will use the phrase “plain and ordinary meaning” below.

35. In order to construe the Challenged Claims of the ’805 Patent, I have reviewed the entirety of the ’805 Patent along with portions of the prosecution history of the ’805 Patent. Consistent with the ’805 Patent disclosure, I have interpreted the terms in the Challenged Claims according to their plain and ordinary meaning as understood by a POSITA, and considered any explicit definitions provided by the specification of the ’805 Patent, where applicable.

VIII. PRIOR ART

A. Broggi

36. “Visual Perception of Obstacles and Vehicles for Platooning,” (“Broggi,” Ex. 1005) was published by Alberto Broggi et al. in September 2000. Broggi describes a method for vehicle navigation using image analysis. Ex. 1005, 164 (“perception of the environment is performed through the processing of images acquired from the vehicle.... The control system... allows the vehicle to follow the road or other vehicles”). The automatic driving system of Broggi (“ARGO”) is embodied in a vehicle (Fig. 1, below) that uses image analysis to perform automated driving tasks. Ex. 1005, 166.



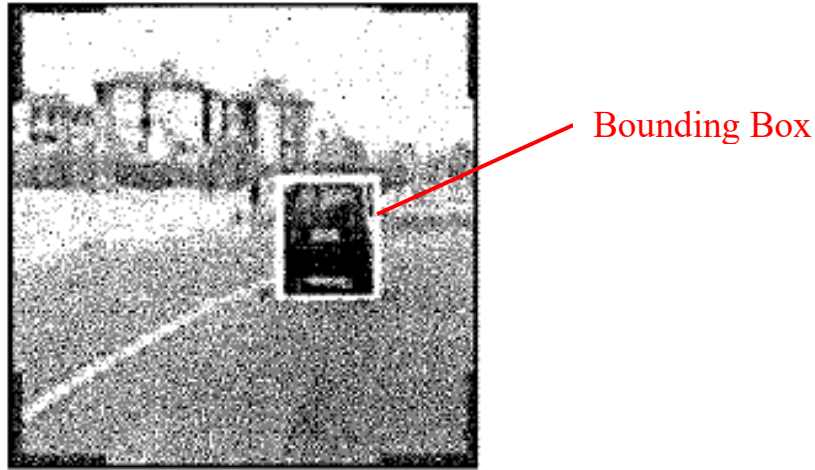
Ex. 1005, Fig. 1.

37. The vision system of Broggi localizes and tracks objects using one or more cameras mounted in the vehicle. Ex. 1005, 164 (“Vehicles are localized and tracked using a singular monocular image sequence whilst a distance refinement is computed using stereo vision.”). Broggi further describes following a preceding vehicle in a method called “platooning.” Ex. 1005, 166 (“Platooning: The automatic following of the preceding vehicle, that requires the localization and tracking of a target vehicle.”). Ex. 1005, 166. During platooning, the system of Broggi localizes and tracks the preceding vehicle so that the following vehicle can navigate to the location of the preceding vehicle. Note that Broggi uses the terms “preceding vehicle” and “leading vehicle” interchangeably, referring to a vehicle in front of another vehicle when platooning. As used herein, “following vehicle,” “trailing

vehicle,” or simply “vehicle” may refer to a vehicle behind a preceding or leading vehicle when platooning.

38. To track and localize objects, such as a preceding vehicle, Broggi’s vision system processes images via a multi-step process. Ex. 1005, 170-172. Edge detection is performed on the images. Ex. 1005, 170-172. The detected edges are then analyzed to identify “a rectangular bounding box” corresponding to a preceding vehicle. Ex. 1005, 171. To this end, Broggi identifies the bounding box by (1) finding the bottom corners of the preceding vehicle and (2) then finding the upper corners/top of the preceding vehicle corresponding to the bottom corners. Ex. 1005, 171. The bottom and top corners of the preceding vehicle are identified using a “traditional pattern matching technique.” Ex. 1005, 171.

39. After identifying the bottom corners, Broggi’s system attempts to identify the top of the preceding vehicle. Ex. 1005, 171 (“This process is followed by the detection of the top part of the bounding box.”). The bounding box defined by the detected bottom and top corners is used to represent the identified location of the preceding vehicle, for example as shown in Fig. 16 (below). Ex. 1005, 172.



Ex. 1005, Fig. 16 (annotated)

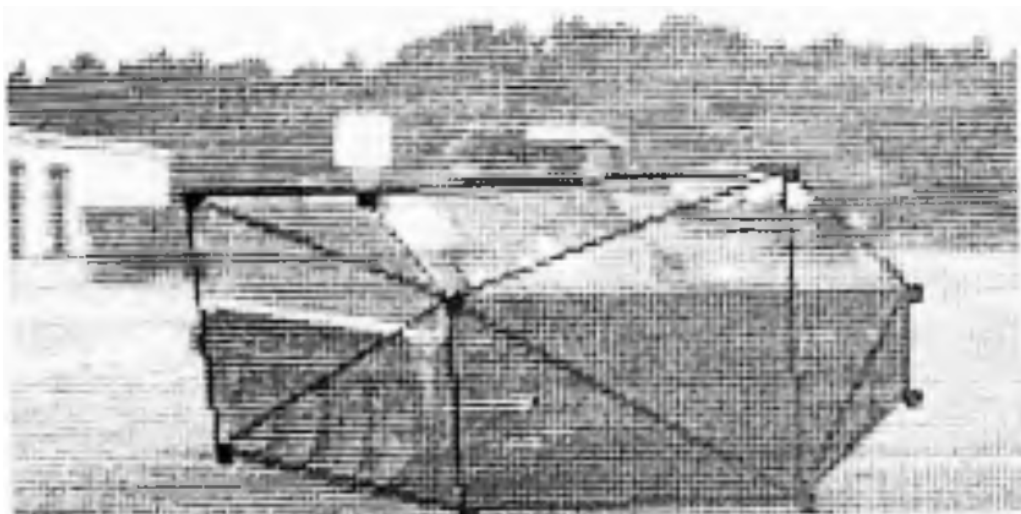
40. If the system fails to detect the bottom corners and/or corresponding top corners, then that candidate is discarded. Ex. 1005, 171-172. For example, Broggi states “[s]ometimes it may happen that... no correct bounding boxes exist. Therefore, a backtracking approach is used.” Ex. 1005, 171-172. Failure to identify the bottom corners of the vehicle results in the failure to identify a correct bounding box, as the bottom of the vehicle is used to determine the bottom of the bounding box. Similarly, failure to identify the top corners of the vehicle results in the failure to identify a correct bounding box, as the top of the vehicle is used to determine the top of the bounding box.

41. The distance to the preceding vehicle is computed using the position of the identified bounding box and then refined using stereo vision. Ex. 1005, 164, 172. The location and distance of the preceding vehicle are then used by the system to

determine a desired path that allows the vehicle to steer autonomously to follow the preceding vehicle. Ex. 1005, 173-175.

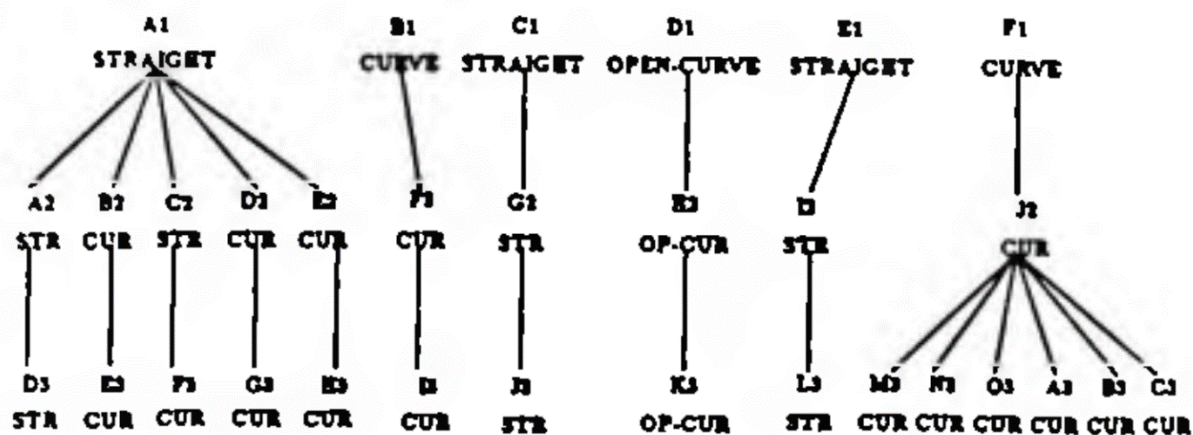
B. Huttenlocher

42. “Object Recognition Using Alignment,” (“Huttenlocher,” Ex. 1006) by Daniel Huttenlocher et al. was presented at the Image Understanding Workshop in February 1987. I understand from counsel that Huttenlocher was published in 1989. Huttenlocher describes a pattern matching technique for identifying an object in an image that “uses edge-based shape features for matching.” Ex. 1006, 373. The matching technique of Huttenlocher is used, for example, in the detection of a vehicle as shown in Fig. 11 (below).



Ex. 1006, Fig. 11 (in part)

43. After using an edge detector on the input image, the edges are segmented (i.e., “chained together”). Ex. 1006, 373. The edge segments are stored in a hierarchical tree structure. Ex. 1006, 373. More specifically, the hierarchical segmentations “form a (multi-rooted) tree, where each region at a coarse scale corresponds to one or more regions at each finer scale.” Ex. 1006, 373, Fig. 4 (below).



Ex. 1006, Fig. 4

44. With the mathematical tree structure defining the interrelationships between the edge segments, matching is performed at two or more levels or stages. First, a potential matching object is identified by “coarse level descriptions [] used to determine which model features can potentially match which image features.” Ex. 1006, 374 (“These possibly matching features form the set of pairs, P, for the alignment algorithm.”). Then, to determine “how well an alignment matches an

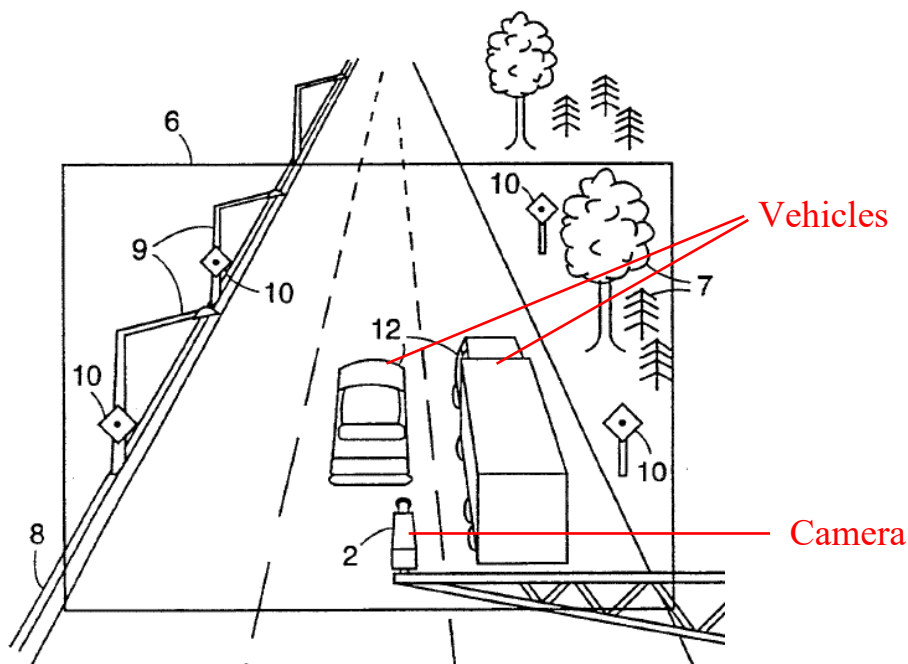
image, fine scale model features are used.” Ex. 1006, 374. Huttenlocher explains that “if the correlation with the image is poor,” then the potential matching object “is eliminated.” Ex. 1006, 374. This process provides a “single best position and orientation” of the object within the image. Ex. 1006, 374.

C. Brady

45. U.S. Patent No. 5,434,927 titled “Method and Apparatus for Machine Vision Classification and Tracking” (“Brady,” Ex. 1007) issued to Mark J. Brady et al. on July 18, 1995. Brady describes a method for identifying and tracking vehicles in a roadway scene (e.g., as in Fig. 1, below). Ex. 1007, 3:59-62.

The method and apparatus disclosed can be utilized for **classifying and tracking vehicles** from a plurality of roadway sites, **the images** from the sites as **provided in real-time by video cameras**.

Ex. 1007, 3:59-62.



Ex. 1007, Fig. 1 (in part, annotated)

46. Brady discloses storing the identified objects (e.g., vehicles) with corresponding positional data in an object list to aid in tracking over time. Ex. 1007, 11:21-25. For example, Brady's system keeps "a vehicle log 102 of all vehicles currently within the scene, including vehicles' associated track histories, inertial history 104 of the scene... and potential future track positions...." Brady 11:21-25.

D. Bertozzi

47. "Automatic Vehicle Guidance: The Experience of the ARGO Autonomous Vehicle," ("Bertozzi," Ex. 1008) was published by Alberto Broggi et al. in 1999. Bertozzi was written by several of the same authors as Broggi, including Alberto Broggi, Massimo Bertozzi, and Alessandra Fascioli, and describes an

implementation of the ARGO vehicle. Broggi, described above, provides a later implementation of the ARGO vehicle further incorporating methods of platooning.

48. Bertozzi describes the ARGO vehicle—the same vehicle contemplated in Broggi—and provides information such as “The Data Acquisition System,” “The Processing System,” “The Output System,” “The Control System,” the functionalities of the vehicle, and “Other Vehicle Equipments and Emergency Features.” *See generally* Ex. 1008, 161-175. Accordingly, Bertozzi merely provides additional information and more detailed information regarding the motor vehicle described in Broggi.

IX. SUMMARY OF OPINIONS

49. It is my opinion that claims 1-2 and 9-10 of the '805 Patent are obvious over Broggi in view of Huttenlocher and Brady.

50. It is my opinion that claims 6-8 and 11 of the '805 Patent are rendered obvious over Broggi in view of Huttenlocher, Brady, and Bertozzi.

X. ANALYSIS

51. I have been asked to provide my opinion as to whether the Challenged Claims of the '805 Patent would have been obvious in view of the prior art. The discussion below provides a detailed analysis of how the prior art references I reviewed disclose, teach, or suggest the limitations of the Challenged Claims of the '805 Patent.

52. As part of my analysis, I have considered the scope and content of the prior art and any potential differences between the claimed subject matter and the prior art.

53. I describe in detail below the scope and content of the prior art, as well as any differences between the claimed subject matter and the prior art, on an element-by-element basis for the Challenged Claims of the '805 Patent. This analysis supports my finding that the limitations of the Challenged Claims of the '805 Patent are disclosed in the prior art, or that the differences between the Challenged Claims of the '805 Patent and the prior art discussed herein are such that the subject matter as a whole would have been obvious to a POSITA at the time of the claimed invention.

54. I describe, in the grounds below, on an element-by-element basis, how the prior art discloses or teaches all elements of the Challenged Claims. Unless otherwise noted, all *italics* refers to claim language, and **bold** or ***bold italics*** is added for emphasis.

A. Ground 1: Claims 1-2 and 9-10 are rendered obvious over Broggi in view of Huttenlocher and Brady

55. It is my opinion that the combined teachings of Broggi, Huttenlocher, and Brady disclose or render obvious, to a POSITA, the subject matter of each and every element of claims 1-2 and 9-10 of the '805 Patent.

1. Reasons to Combine Broggi, Huttenlocher, and Brady

a) Analogous Art

56. Broggi, Huttenlocher, and Brady are analogous art to the '805 patent. Broggi pertains to the same field of endeavor as the '805 patent: image processing and the detection of objects (e.g., vehicles) in images, including image processing in the context of vehicle guidance. Ex.1001, 1:6-9 (“assisting vehicle guidance on the basis of image data”); Ex.1005, 164 (Broggi presents “methods for sensing obstacles and vehicles”), 165, 166 (system functionalities include “automatic following of the preceding vehicle, that requires the localization and tracking of a target vehicle”), 170-172 (describing vehicle detection). Broggi is reasonably pertinent to a particular problem addressed by the '805 patent, namely, calculating a path to a destination based on image analysis. Ex.1001, 3:13-22, 30-33; Ex.1005, 173-175, Fig. 21. Accordingly, Broggi is analogous art to the '805 patent.

57. Huttenlocher is analogous art in the same field of endeavor as the '805 patent: image processing and the detection of objects (e.g., vehicles) in images. Ex.1006, 375, Figs. 2, 11 (image detection of a “personnel carrier”). Huttenlocher is reasonably pertinent to particular problems addressed by the '805 patent, namely, object detection through image analysis and associated data processing/storage. Ex.1001, 2:32-41 (“the image data undergo an edge detection and edge segmentation,” “interrelationships are stored in a mathematical tree structure,”

“these edge segments are then analyzed”); Ex.1006, 373 (“image is processed by an edge detector,” “[a] hierarchy of curve segmentations can be obtained,” “the hierarchy forms a tree of segments”), 374 (“[p]oints for use by the alignment algorithm are obtained from the features” based on the types of segments stored in the multi-scale segmentation tree). Accordingly, Huttenlocher is analogous art to the ’805 patent.

58. Brady is analogous art in the same field of endeavor as the ’805 patent: image processing and the detection of objects (e.g., vehicles) in images, including image processing to identify and “track objects within the roadway scene, such as a vehicle[.]” Ex.1007, abstract. Brady is reasonably pertinent to a particular problem addressed by the ’805 patent, namely, vehicle detection through image analysis and storing related information. Ex.1001, 2:48-52 (object “is stored, along with the corresponding relative positional data, in an object list”); Ex.1007, 11:21-25 (“keeping a vehicle log 102 of all vehicles currently within the scene, including vehicles’ associated track histories, inertial history 104 of the scene...and potential future track positions”). Accordingly, Brady is analogous art to the ’805 patent.

b) Motivation to Combine Broggi and Huttenlocher

59. A POSITA would have been motivated to implement Huttenlocher’s pattern matching technique utilized for object recognition as part of Broggi’s vehicle detection methods because doing so would have been the combination of prior art

elements (Broggi's vehicle detection using a "traditional pattern matching technique" and Huttenlocher's known pattern matching technique) according to known methods to yield predictable results (using Huttenlocher's known pattern matching technique as Broggi's "traditional pattern matching technique" for vehicle detection).

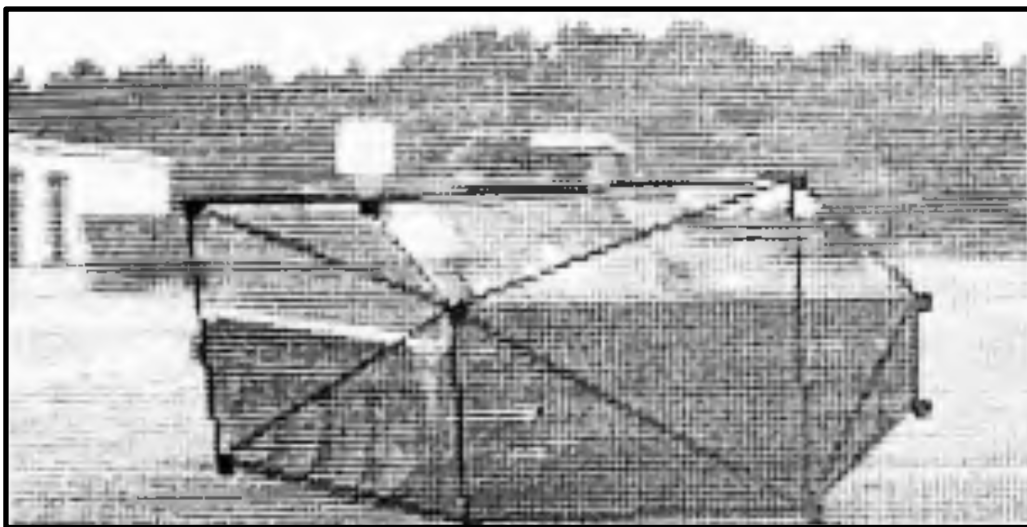
60. Further, a POSITA would have been motivated to make the combination because Broggi contains an explicit teaching, suggestion, or motivation (calling for use of a "traditional pattern matching technique") that would have led a POSITA to modify Broggi to implement Huttenlocher's known pattern matching technique.

61. Both Broggi and Huttenlocher disclose detecting edges in images. Ex.1005, 171; Ex.1006, 373-374. It would have been obvious to a POSITA that the combination of Broggi and Huttenlocher would implement Broggi's edge detection, Huttenlocher's edge detection, or both Broggi's edge detection and Huttenlocher's edge detection. In this regard, using either Broggi's edge detection or Huttenlocher's edge detection would have been the simple substitution of one known element (Broggi's or Huttenlocher's edge detection) for another (the other of Huttenlocher's or Broggi's edge detection). Further, using both Broggi's and Huttenlocher's edge detection would be the combination of familiar elements according to known methods to yield predictable results.

62. In the combination, Broggi implements Huttenlocher's pattern matching technique—that segments edges, stores edge segments in a multi-scale tree, and analyzes the edge segments—as part of detecting the location of a preceding vehicle. Huttenlocher's pattern matching technique would be applied to the images obtained by Broggi to identify “possibly matching features” corresponding to the bottom corners and/or the top of the preceding vehicle. *See* Ex.1005, 170-171; Ex.1006, 370, 373-374; *see infra* [1.4.1]-[1.4.3]. For example, the image data may be processed to detect edges (in accordance with Broggi and/or Huttenlocher) and Huttenlocher's pattern matching technique would be applied to segment the edges, store edge segments in a multi-scale tree, and analyze the edge segments to detect the bottom corners and/or the top of the preceding vehicle. A POSITA would have understood, based on Broggi's description, that Huttenlocher's pattern matching technique may be utilized for detecting the bottom corners, the top, or both the bottom corners and the top of the preceding vehicle. Ex.1005, 170-171. Once the preceding vehicle is identified and a corresponding location is determined, Broggi automatically follows the preceding vehicle by calculating a steering angle for a desired path to the location of the preceding vehicle and controls the steering of the vehicle accordingly. *See infra* [1.3], [9.0]. Implementing Huttenlocher's pattern matching technique would provide advantages for Broggi, such as efficient vehicle detection and efficient use of processing resources because Huttenlocher's

pattern matching technique requires little information and operates quickly. *See* Ex.1006, 379 (“alignment can be performed with a small amount of information”).

63. A POSITA would have had a reasonable expectation of success in using Huttenlocher’s pattern matching technique as Broggi’s “traditional pattern matching technique” for vehicle detection because Huttenlocher provides an explicit example of using its disclosed pattern matching technique to detect a vehicle. Ex.1005, 171; Ex.1006, 375; *see also* Ex.1006, Figs. 2, 11 (showing a “personnel carrier used in recognition,” and the “[l]ocal alignment of two views of a personnel carrier.”).



Ex.1006, Fig. 11 (in part)

**c) Motivation to Combine Broggi and Huttenlocher with
Brady**

64. A POSITA would have been motivated to modify the combined Broggi-Huttenlocher method discussed above to implement Brady’s teaching of

keeping an object list containing identified vehicle(s) with corresponding positional data (e.g., a vehicle log) because doing so would have been the combination of prior art elements (platooning, per Broggi-Huttenlocher, with Brady's teaching of keeping a vehicle log) according to known methods to yield predictable results (platooning, per Broggi-Huttenlocher, using a vehicle log to keep track of a preceding vehicle and associated position information).

65. Broggi provides “an experimental autonomous vehicle equipped with vision systems and automatic steering capability” for lane following and platooning, including a processing system “based on a standard 450 MHz Pentium II processor.” Ex.1005, 165. Despite Broggi's focus on vehicle detection and tracking for platooning, Broggi omits implementation details as to how the associated data is processed and stored. *See generally* Ex.1005, 170-172; *see also* Ex.1005, 173 (noting that the described system “is able to continuously capture images into a circular buffer in main memory, therefore, not requiring a synchronization with the processing”).

66. Brady provides such implementation details in the same context of “classifying and tracking vehicles” captured “in real-time[.]” Ex.1007, 3:59-62, 11:21-25; *see also* Ex.1005, 172 (discussing “tracking an already found” vehicle). In the combination, Broggi stores information regarding a preceding vehicle—identified using the combination of Broggi and Huttenlocher—in a vehicle log, per

Brady. Ex.1007, 11:21-25. Consistent with the disclosures of Broggi and Brady, the vehicle log would include an object list identifying the preceding vehicle and associated positional information. More specifically, the positional information associated with the preceding vehicle included in the object list would at least include a relative location of the preceding vehicle and an associated distance, in accordance with Broggi's platooning method. *See* Ex.1007, 11:21-25 (noting a vehicle log "including vehicles' associated track histories, inertial history 104 of the scene... and potential future track positions"). *See infra* [1.4.4]; Ex.1005, 170 ("[T]he [preceding] vehicle is localized and tracked using a single monocular image sequence; the correct distance is refined thanks to stereo vision."). Broggi's method would reference and update the object list over time (e.g., updating the positional information to reflect the current location of the preceding vehicle and/or keep a log of past locations) to perform the functions associated with platooning, such as determining a desired path and associated steering angle. Ex.1005, 173, Fig. 21.

67. A POSITA would have looked at Brady's teachings at least because they would have advantageously provided a known mechanism for tracking vehicle positions over time, which would improve Broggi's platooning through the accurate and consistent tracking of the preceding vehicle positions used in the associated vehicle path determinations, thereby improving the user experience during platooning. Ex.1007, 11:21-25.

68. A POSITA would have had a reasonable expectation of success in combining Brady's object list with the Broggi-Huttenlocher combination because Brady discloses that such an object list may be used in the context of identifying and tracking vehicles in real-time, as performed in the Broggi-Huttenlocher combination. Ex.1007, 11:21-25, 1:8-11 ("tracking objects in images provided by real-time video"); Ex.1005, Fig. 19, Table I (showing image acquisition, "Vehicle Detection," and "Vehicle Tracking"). Thus, Brady provides implementation details for maintaining and storing information for vehicle tracking suitable for use with Broggi's platooning method. Accordingly, a POSITA would have had a reasonable expectation of success in implementing Brady's vehicle log to track preceding vehicles and associated positional information as part of the combined Broggi-Huttenlocher method of platooning.

2. Claim 1

[1.0] A method for assisting guidance of a motor vehicle on the basis of image data, the method comprising:

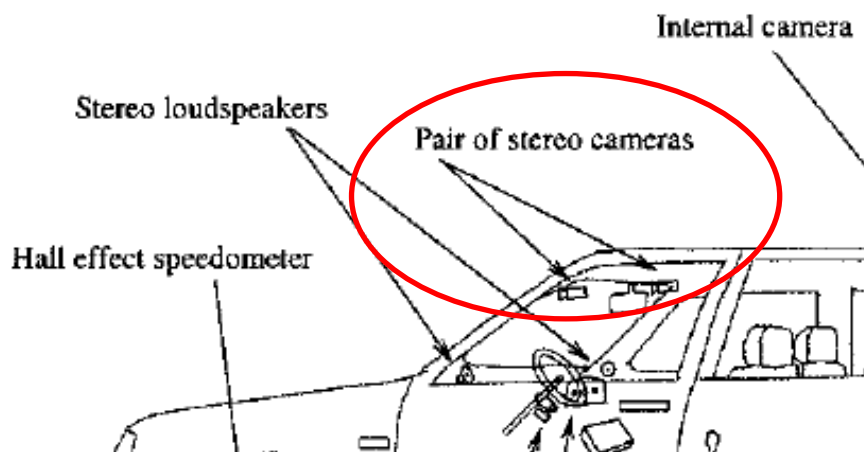
69. To the extent that the preamble is limiting, Broggi discloses or at least renders obvious *a method for assisting guidance of a motor vehicle* (a method of controlling steering of a motor vehicle to follow a preceding vehicle) *on the basis of image data* (based on a monocular image sequence and/or stereo vision) because

Broggi discloses platooning, which provides assisted guidance and controls steering of a motor vehicle to follow a preceding vehicle based on captured image data.

70. **First**, Broggi discloses *a method for assisting guidance of a motor vehicle*. Broggi is a paper that “presents the methods for sensing obstacles and vehicles...performed through the processing of images acquired from the vehicle.” Ex. 1005, 164. More specifically, Broggi describes “an experimental autonomous vehicle equipped with vision systems and automatic steering capability.” Ex. 1005, 165. Broggi explains that there are many functionalities that autonomous must be able to perform, including obstacle and vehicle detection, “[r]oad [f]ollowing, namely, the automatic movement along a predefined path,” and “[p]latooning, namely, the automatic following of a preceding vehicle.” Ex. 1005, 164. Broggi further explains that platooning is the “**automatic following of the preceding vehicle**, that requires the localization and tracking of a target vehicle.” Ex. 1005, 166. This disclosure of platooning teaches a method of assisting guidance of the motor vehicle because Broggi describes automatic steering of an autonomous vehicle to follow a preceding vehicle.

71. **Second**, Broggi’s platooning, i.e., the *assisting guidance*, is *on the basis of image data*. Broggi explains that “an autonomous vehicle must be able to **detect vehicles and potential obstacles** on its path in order to perform ... [p]latooning.” Ex. 1005, 164; *see also* Ex. 1005, 170 (“The platooning functionality depends on a

robust detection of the distance and speed of the preceding vehicle.”). The detection of vehicles is performed using image data captured from cameras within the vehicle. *See, e.g.*, Ex. 1005, 165 (“The images acquired by a stereo rig placed behind the windshield are analyzed in real-time by the computing system located in the boot.”). This is reflected in Fig. 1 of Broggi, below, which shows an example of an “**autonomous vehicle equipped with vision systems** and automatic steering capability.” Ex. 1005, 165.



Ex. 1005, Fig. 1 (in part, annotated)

72. As described in Broggi, “[v]ehicles are localized and tracked using a **single monocular image sequence** whilst a distance refinement is computed using **stereo vision**.” Ex. 1005, 164. “A mechanical device provides autonomous steering capabilities.... The **output fed by the vision system is used to turn the steering**

wheel to maintain the vehicle inside the lane or follow the leading vehicle.”

Ex. 1005, 166.

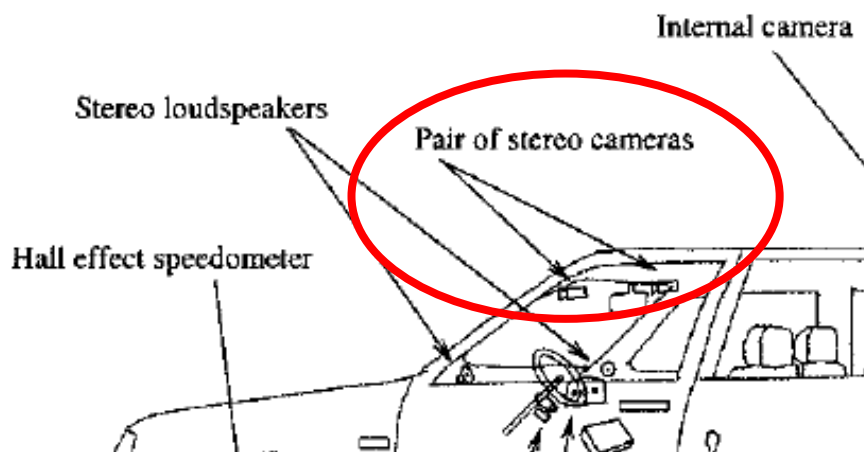
73. Thus, Broggi discloses or at least renders obvious *a method for assisting guidance of a motor vehicle* (controlling steering of a motor vehicle to follow a preceding vehicle) *on the basis of image data* (based on a monocular image sequence and/or stereo vision).

[1.1] acquired image data using an imaging sensor from a surrounding field of the motor vehicle³

74. Broggi discloses or at least renders obvious *acquir[ing] image data* (acquiring image data using a monocular image sequence and/or stereo vision) *using an imaging sensor* (acquired from one and/or both of the stereo cameras) *from a*

³ Limitation [1.1] recites “acquired” image data. It is unclear whether this is intended to be a gerund (i.e., “acquiring”). Without conceding the term is clear, I am interpreting “acquired” as “acquiring” for the purposes of this Declaration. This is in line with the specification of the ’805 patent and independent claim 13, which similarly describes the use of an image sensor “to acquire image data.” See Ex. 1001, 2:56-64 (“an imaging sensor (10, 22) for acquiring image data from the field surrounding the motor vehicle”), Claim 13 “an imaging sensor configured to acquire image data”).

surrounding field of the motor vehicle (acquired images are from the surrounding environment of the motor vehicle, such as the surrounding field in front of the vehicle where a preceding vehicle of a platoon is positioned) because Broggi discloses image data is captured using cameras mounted within the motor vehicle and includes the environment around a motor vehicle during platooning. As reflected in Fig. 1, below, Broggi acquires image data from a surrounding field of the motor vehicle using a pair of cameras mounted within the vehicle.



Ex. 1005, Fig. 1 (in part, annotated)

75. **First**, Broggi teaches *acquir[ing] image data* using a monocular image sequence and/or stereo vision using stereo cameras within a motor vehicle. Fig. 1 of Broggi, above, shows an example of an “autonomous vehicle equipped with vision systems and automatic steering capability.” Ex. 1005, 165. This autonomous vehicle

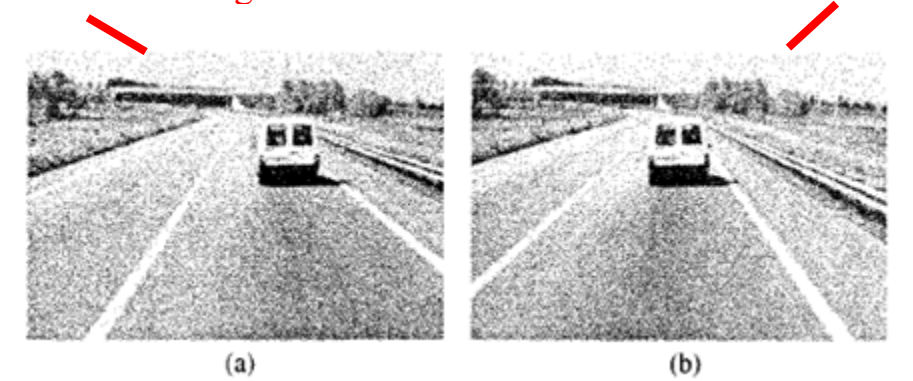
acquires image data “by a **stereo rig** placed behind the windshield,” which utilizes “passive sensors...to sense the surrounding environment.” Ex. 1005, 165. In particular, Broggi explains that the sensing system includes a “stereoscopic vision system consisting of two low-cost synchronized **cameras able to acquire pairs of grey level images** simultaneously.” Ex. 1005, 165. As reflected in Fig. 1, above, “[t]he cameras lie inside the vehicle at the top corners of the windshield, so that the longitudinal distance between the two cameras is maximum.” Ex. 1005, 165. Broggi teaches that “[v]ehicles are localized and tracked using **a single monocular image sequence** whilst a distance refinement is computed using **stereo vision**.” Ex. 1005, 164. Accordingly, Broggi teaches *acquir[ing] image data* by acquiring images using a monocular image sequence and/or stereo vision using stereo cameras within a motor vehicle.

76. Broggi teaches that images are acquired *using an imaging sensor* because images are acquired from “passive sensors,” and more specifically, one and/or both of the stereo cameras in the stereo rig discussed immediately above. As illustrated in Fig. 2, below, and Broggi’s accompanying disclosure, Broggi teaches that the stereo cameras capture images of the surrounding field of the motor vehicle. Ex. 1005, Fig. 2, 164-165 (“passive sensors...to **sense the surrounding environment**”), 166 (showing “(a) the left stereo images” and “(b) the right stereo image”); *see also* Ex. 1005, 165 (“the use of sensors has been restricted to passive

ones, such as cameras”), 167 (discussing object detection results shown in Fig. 3 with respect to “the image captured by the left camera”).

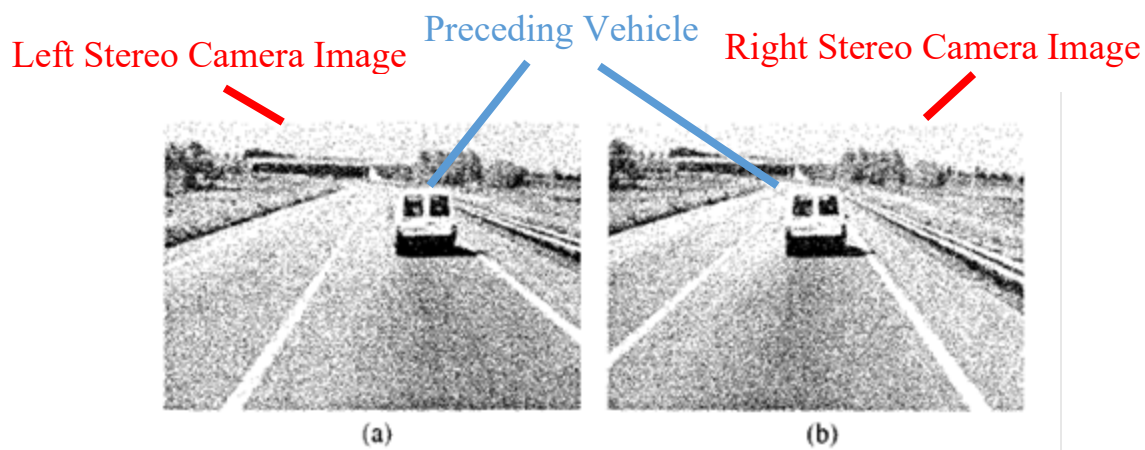
Left Stereo Camera Image

Right Stereo Camera Image



Ex. 1005, Fig 2 (annotated)

77. **Second**, Broggi teaches that images are acquired *from a surrounding field of the motor vehicle* because the acquired images are from the surrounding environment of the motor vehicle, such as the surrounding field in front of the vehicle where a preceding vehicle of a platoon is positioned. For instance, as shown in Fig. 2, below, the surrounding field includes the forward-facing area ahead of the vehicle where a preceding vehicle of a platoon is positioned. Ex. 1005, 164, Fig. 2.



Ex. 1005, Fig 2 (annotated)

78. In view of the specification of the '805 patent, a POSITA would have understood “a surrounding field of the motor vehicle” to include an area outside the motor vehicle that may be captured by an imaging sensor (camera) but does not require the entire surrounding field (e.g., 360-degree view) of the motor vehicle. For example, image sensor 22 of the '805 patent is clearly illustrated as facing one direction, specifically towards the rear of the vehicle as shown in Fig. 2 of the '805 patent (below). Ex. 1001, 7:15-16. In this manner, Fig. 2 of the '805 patent provides an explicit example where the “surrounding field of the motor vehicle” captured by the camera is the area outside and around the rear of the motor vehicle.

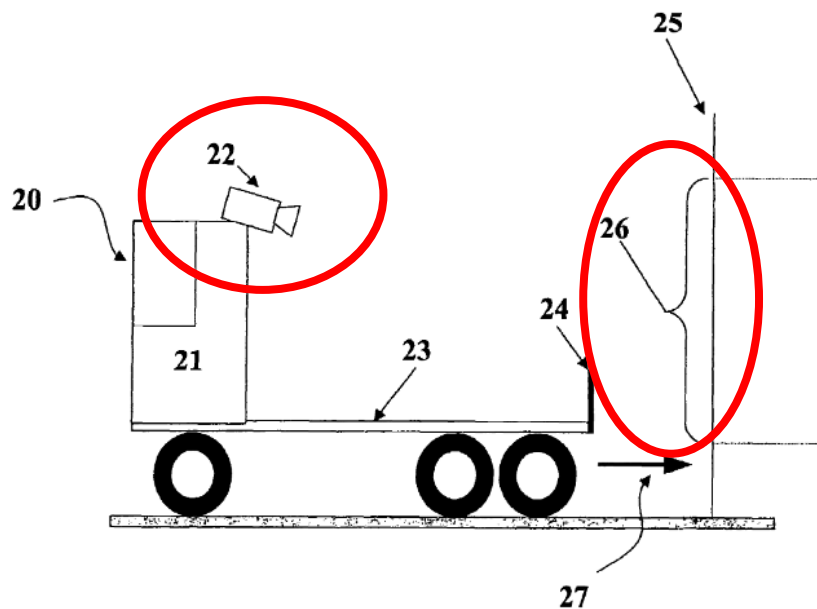
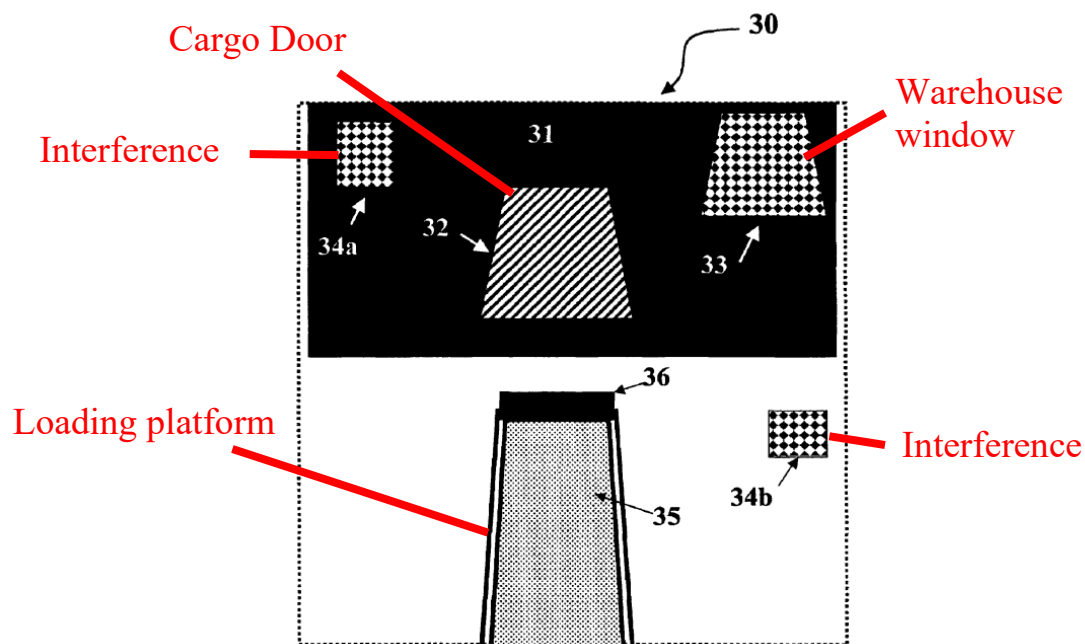


Figure 2

Ex. 1001, Fig. 2 (annotated)

79. Consistent with Fig. 2, the exemplary image shown in Fig. 3 of the '805 patent (below) likewise illustrates “the surrounding field of the motor vehicle” captured by the camera being a limited field of view of the area outside and around the rear of the motor vehicle.



Ex. 1001, Fig. 3 (annotated)

80. In particular, the surrounding field of the motor vehicle shown in Fig. 3 of the '805 patent includes the area around the rear of the vehicle's loading platform 35, including the warehouse cargo door 32 and warehouse window 33. Ex. 1001, 7:13-32 ("loading platform (23, 35)... cargo door (26, 32)... Object 33 corresponds to another rectangular structure, for example a window of warehouse..."). None of the descriptions or examples from the '805 patent support a full 360-degree view around the vehicle. In fact, the arrangements described in the '805 patent do not appear to be capable of capturing a full 360-degree view around the vehicle.

81. Therefore, in light of the specification of the '805 patent, the claimed *surrounding field of the motor vehicle* includes an area outside the motor vehicle that

may be captured by an imaging sensor (camera) but does not require the entire surrounding field (e.g., 360 degree view) of the motor vehicle. And as discussed above, Broggi teaches capturing images from the surrounding environment of the motor vehicle, such as the surrounding field in front of the vehicle where a preceding vehicle of a platoon is positioned, using stereo cameras.

82. Thus, Broggi discloses or at least renders obvious *acquir[ing] image data* (acquiring image data using a monocular image sequence and/or stereo vision) *using an imaging sensor* (acquired from one and/or both of the stereo cameras) *from a surrounding field of the motor vehicle* (acquired images are from the surrounding environment of the motor vehicle, such as the surrounding field in front of the vehicle where a preceding vehicle of a platoon is positioned).

[1.2] extracting from the acquired image data positional parameters of at least one potential destination relative to the motor vehicle; and

83. Broggi discloses or at least renders obvious *extracting from the acquired image data positional parameters* (a bounding box defining a relative location of the preceding vehicle and an associated distance are extracted from images acquired using a monocular image sequence and/or stereo vision) *of at least one potential destination relative to the motor vehicle* (location of preceding vehicle relative to the motor vehicle) because Broggi renders obvious extracting a location

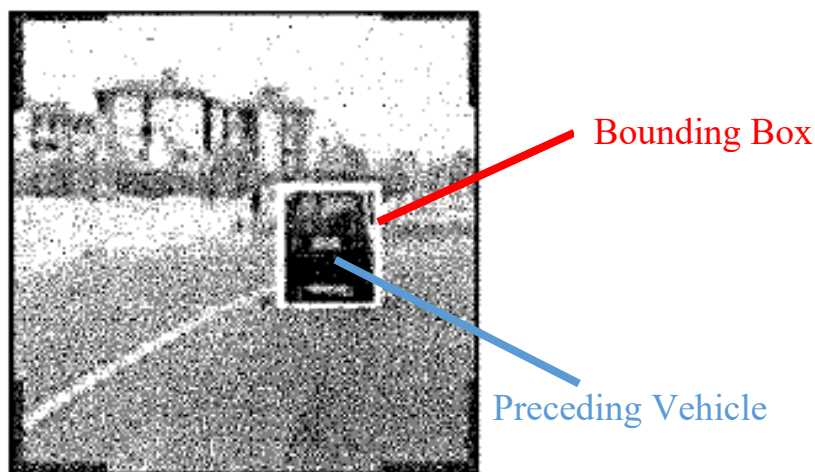
of a preceding vehicle in a platoon from the image data.⁴ To this end, Broggi describes that a bounding box defining a relative location of the preceding vehicle and an associated distance are extracted from images acquired using a monocular image sequence and/or stereo vision to determine the location of a preceding vehicle relative to the motor vehicle.

84. As discussed above in the analysis of limitation [1.1], Broggi acquires images using a monocular image sequence and/or stereo vision. These images are used for platooning, i.e., assisting vehicle guidance, in which Broggi detects and tracks vehicles and utilizes “the estimated position of the preceding vehicle.” Ex. 1005, 164-165. The autonomous vehicle detailed in Broggi “is able to determine its position with respect to the lane, to compute road geometry, to detect generic obstacles on the path, and **to localize a leading vehicle**” using images acquired by the cameras in the vehicle. Ex. 1005, 165.

85. **First**, Broggi *extract[s] ... positional parameters [from the acquired image data]* by extracting a relative location and associated distance of the preceding

⁴ Limitation [1.2] claims “extracting,” and limitations [1.4.0]-[1.4.4] provide additional requirements regarding the claimed “extracting.” These additional requirements are met by additional references, as detailed in my analysis of limitations [1.4.0]-[1.4.4] below.

vehicle from the acquired image data as part of platooning. Ex. 1005, 170 (“The platooning functionality depends on a robust detection of the distance and speed of the preceding vehicle.... [T]he [preceding] vehicle is localized and tracked using a single monocular image sequence; the correct distance is refined thanks to stereo vision.”); *see* Ex.1001, 3:13-22 (describing “**relative positional data**”). Broggi’s teaching is similar in scope to the ’805 patent, which describes relative position data. Ex.1001, 3:13-22 (describing “**relative positional data**”), 6:8-13 (“object...whose position relative to the imaging sensor is known”). This extraction is performed on image data through the analysis of “a specific region of the image” acquired using a monocular image sequence and/or stereo vision. Ex. 1005, 170; *see also* Ex. 1005, 171 (describing “the search area” for each image). The relative location of the preceding vehicle is represented by a bounding box. Ex. 1005, 171 (describing bounding box detection as determining “two corners representing the bottom of the bounding box around the vehicle” and detecting “the top part of the bounding box, which is looked for in a specific region whose location is again determined by perspective and size constraints”). An example of a bounding box and corresponding preceding vehicle is shown in Fig. 16, below. Ex. 1005, 172.



Ex. 1005, Fig. 16 (annotated)

86. Broggi explains that “[t]he platooning functionality depends on a robust detection of the distance and speed of the preceding vehicle.” Ex. 1005, 170. To this end, Broggi describes the use of a vehicle detection algorithm to generate sufficiently reliable results. Ex. 1005, 170.⁵ This includes a distance refinement, where “[t]he distance to the leading vehicle is computed with the knowledge of the camera calibration.” Ex. 1005, 172. Distance refinement is achieved using both the left and right stereo images (acquired using stereo vision), as reflected in Fig. 17, below. Ex. 1005, 172; *see also* Ex. 1005, 164 (“Vehicles are localized and tracked

⁵ Broggi’s vehicle detection algorithm is discussed in more detail in the analysis of limitations [1.4.0]-[1.4.4], which further relate to the identification of objects.

using a single monocular image sequence whilst a distance refinement is computed using stereo vision.”).



Fig. 17. Distance refinement: (a) left and right stereo images; (b) incorrect result of the detection step (the lower part of the bounding box indicates a wrong distance); (c) superimposition of stereo images with a null offset; and (d) superimposition of correctly shifted stereo images.

Ex. 1005, Fig. 17

87. The offset of the location of the bounding boxes within the stereo images (defining a relative location of the preceding vehicle) is used to compute the distance to the preceding vehicle relative to the vehicle. Ex. 1005, 172 (“Since the

stereo set-up is known, once the same pattern enclosed into the bounding box is detected in the right image, a simple triangulation allows to measure the vehicle distance: the offset of the bounding boxes containing the vehicle, measured in both images, is used to compute the vehicle distance.”). Accordingly, Broggi teaches *extracting from the acquired image data positional parameters* including (1) the location of the preceding vehicle, as identified by the bounding box; and (2) the distance to the preceding vehicle. Both the location of the preceding vehicle and the distance to the preceding vehicle are determined *from the acquired image data* because Broggi determines them using images acquired using a monocular image sequence and/or stereo vision, as described in detail above and further reflected in Figs. 16-17 above.

88. **Second**, a preceding vehicle is a *potential destination* because platooning, as described in Broggi, is the automatic following of a preceding vehicle. “When the Platooning functionality is activated, the target point is centered on the preceding vehicle[.]” Ex. 1005, 174. Thus, the extracted positional parameters (e.g., location and distance) of the preceding vehicle represent at least one potential destination relative to the following motor vehicle. Accordingly, Broggi’s disclosure of the location of a preceding vehicle renders obvious the claimed *potential destination*. A *potential destination* being an object—such as a preceding vehicle—is consistent with how the ’805 patent uses the term “destination” in the

specification, referring to a destination as an object, such as a cargo door. Ex. 1001, 7:25-29 (“geometric objects typically corresponding to a potential destination”), 7:29-31 (“the image of a cargo door (26) sought as a destination”), 7:50 (“the destination (cargo door)”).

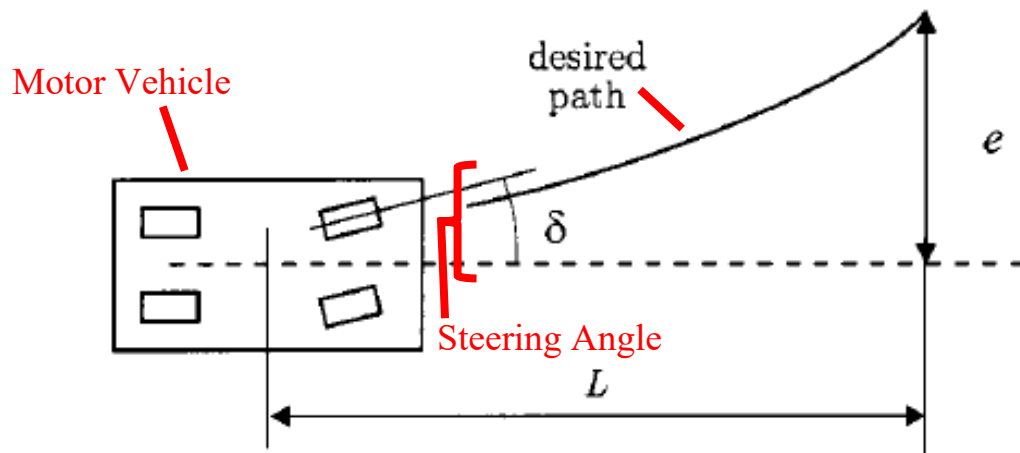
89. Thus, Broggi discloses or at least renders obvious *extracting from the acquired image data positional parameters* (a bounding box defining a relative location of the preceding vehicle and an associated distance extracted from images acquired using a monocular image sequence and/or stereo vision) *of at least one potential destination relative to the motor vehicle* (location of preceding vehicle relative to the motor vehicle).

[1.3] calculating at least one trajectory describing an optimized travel path using the positional parameters so as to assist a subsequent vehicle guidance for at least one of the potential destinations,

90. Broggi discloses or at least renders obvious *calculating at least one trajectory describing an optimized travel path using the positional parameters* (calculating a steering angle δ for a desired path using the relative location and associated distance of the preceding vehicle) *so as to assist a subsequent vehicle guidance for at least one of the potential destinations* (the steering angle is used for controlling steering of a motor vehicle during platooning to the location of the preceding vehicle) because Broggi discloses calculating a steering angle for a desired path using the relative location and associated distance of the preceding

vehicle to control steering of a motor vehicle during platooning to guide the motor vehicle to the location of the preceding vehicle.

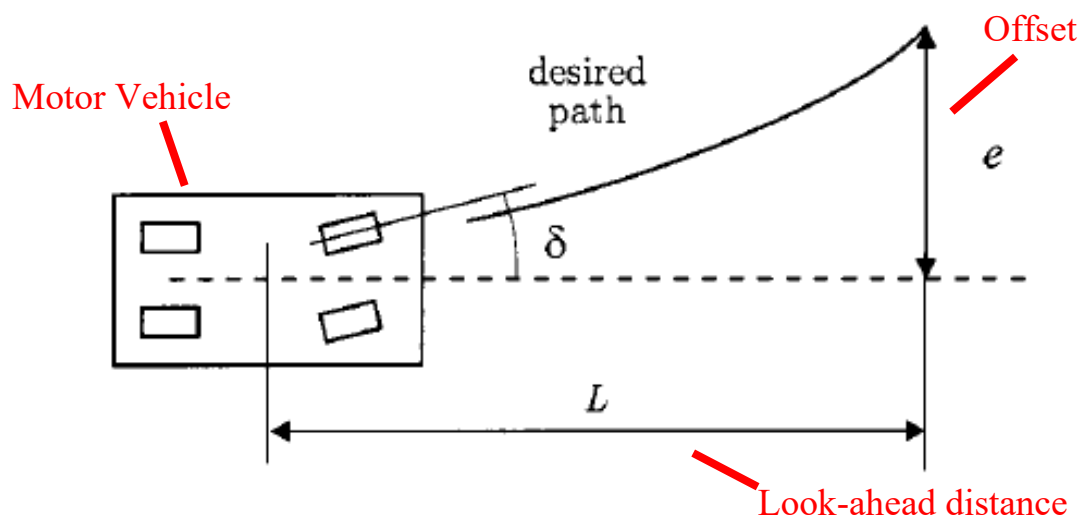
91. **First**, Broggi discloses *calculating at least one trajectory describing an optimized travel path* by calculating a steering angle δ for a desired path. Broggi illustrates an example of a motor vehicle, steering angle δ , and corresponding desired path in Figure 21, below:



Ex. 1005, Fig. 21 (annotated)

92. Figure 21 shows a steering angle δ representing an angle to the left of a forward path for the motor vehicle. *See* Ex. 1005, Fig. 21. This steering angle corresponds to the angle of the desired path from the current heading of the motor vehicle. *See* Ex. 1005, Fig. 21, 173. The steering angle is a trajectory describing the desired path because the steering angle defines the direction the vehicle will follow along the desired path from the current position. Ex.1005, Fig. 21, 173. The desired

path extends from the current position of the motor vehicle to the target point, which “is centered on the preceding vehicle” during platooning. *See* Ex. 1005, Fig. 21, 173-175. The target point is ahead of the motor vehicle by a “look-ahead distance L ” and an “offset e existing between the vehicle heading and the desired path[.]” *See* Ex. 1005, Figs. 21-22, 173-175.



Ex. 1005, Fig. 21 (annotated)

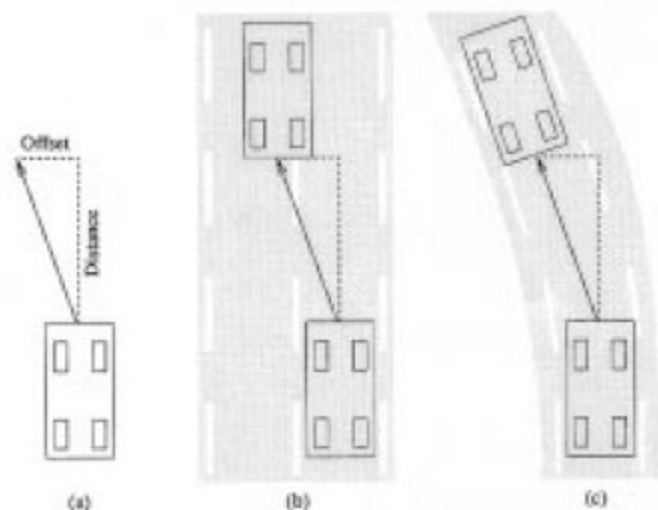


Fig. 22. Evaluation of the proper error signal for a Platooning application.

Ex. 1005, Fig. 22

93. **Second**, the desired path of Broggi is an *optimized travel path* because—as shown in Figs. 21 and 22—it is used “to automatically *follow* the vehicle ahead” as part of the described platooning functionality. Ex. 1005, 175. In this manner, the desired path of Broggi is an optimized path of travel for the vehicle to achieve platooning through following the vehicle ahead because it provides a path reachable in view of Broggi’s vehicle capabilities, which is consistent with the ’805 patent rejecting destinations that are unreachable based on the capability of the vehicle when calculating the trajectory describing an optimized path. Ex.1001, 6:35-39 Ex. 1001, 6:35-39 (rejecting unreachable destinations when calculating an optimized path), claims 6-7; Ex. 1005, 173 (citing Ex. 1008); Ex. 1008, 171 (ARGO control system considers vehicle capability in steering wheel movements). Broggi

discloses the use of “a variable gain proportional controller” that is “**optimized** for the Road Following task,” including implementing improvements for platooning functionality. Ex. 1005, 173. “The command steering angle δ is obtained with a variable gain proportional controller.” Ex. 1005, 173-174, Fig. 20. “[T]he offset e is inherently noisy,” so “[t]o reduce the disturbances, e is preliminary filtered with a moving average filter.” Ex. 1005, 174. “The efficiency of the Platooning control algorithm is recovered by scaling the tracking error e' measured at L' to an estimated offset error $e(v)$,” which “provides the suitable $e(v)$ regardless of the actual distance of the target vehicle.” Ex. 1005, 175.

94. The '805 Patent fails to define “optimized travel path,” and does not limit an “optimized travel path” to a singular path. Instead, the '805 Patent indicates there can be multiple trajectories and associated optimized travel paths. *See, e.g.*, Ex. 1001, 2:48-52 (“to this end, ***at least one trajectory*** describing an optimized travel path is computed”), 3:62-63.

95. **Third**, Broggi discloses the steering angle δ for a desired path is *calculat[ed]... using the positional parameters*, such as the relative location and associated distance of the preceding vehicle extracted from the acquired image data.

96. As described above for limitation [1.2], Broggi extracts *positional parameters* by extracting a relative location and associated distance of the preceding vehicle from the acquired image data as part of platooning. Ex. 1005, 170-172. More

specifically, images are acquired and then processed through steps including inverse perspective mapping (IPM), lane detection, obstacle detection, and vehicle detection, as reflected in Figure 19 and Table I, below:

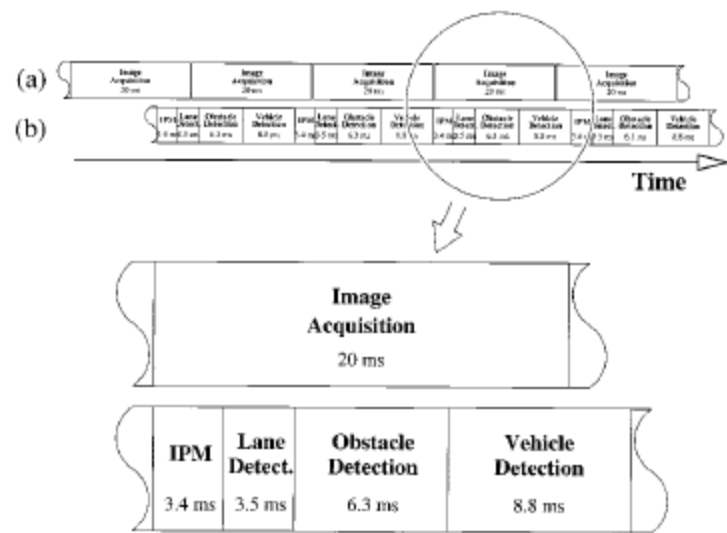


Fig. 19. Image acquisition (a) and processing (b) performance.

Ex. 1005, Fig. 19

TABLE I
TIMINGS OF PROCESSING STEPS

	Pentium 200MMX	Pentium II 450MMX	Speedup
IPM	9.9 ms	3.4 ms	2.9
Lane Detection	14.4 ms	3.5 ms	4.1
Obstacle Detection	17.5 ms	6.3 ms	2.7
Vehicle Tracking	24.8 ms	8.8 ms	2.8
Vehicle Detection	47.6 ms	19.9 ms	2.4

Ex. 1005, Table I

97. The extraction of a relative location and associated distance of the preceding vehicle from the acquired image data as part of platooning, discussed

above for limitation [1.2], occurs as part of the vehicle detection step. *See* Ex. 1005, 170-172 (Section IV. Vehicle Detection). As reflected in Figure 20, below, the data collected from image acquisition and processing, including the vehicle detection data such as a relative location and associated distance of the preceding vehicle, is passed to a supervisor (a software module that runs on a Pentium II processor). *See* Ex. 1005, 165, 173, Fig. 20. “[T]he supervisor uses the results to select the most appropriate gain for the proportional controller and estimate the error signal.” Ex. 1005, 173. “The command steering angle δ is obtained with a variable gain proportional controller.” Ex. 1005, 173; *see also* Ex. 1005, 164-165 (“The steering control for the Platooning functionality is based on a gain scheduled proportional controller whose error input is **evaluated using the estimated position of the preceding vehicle.**”).

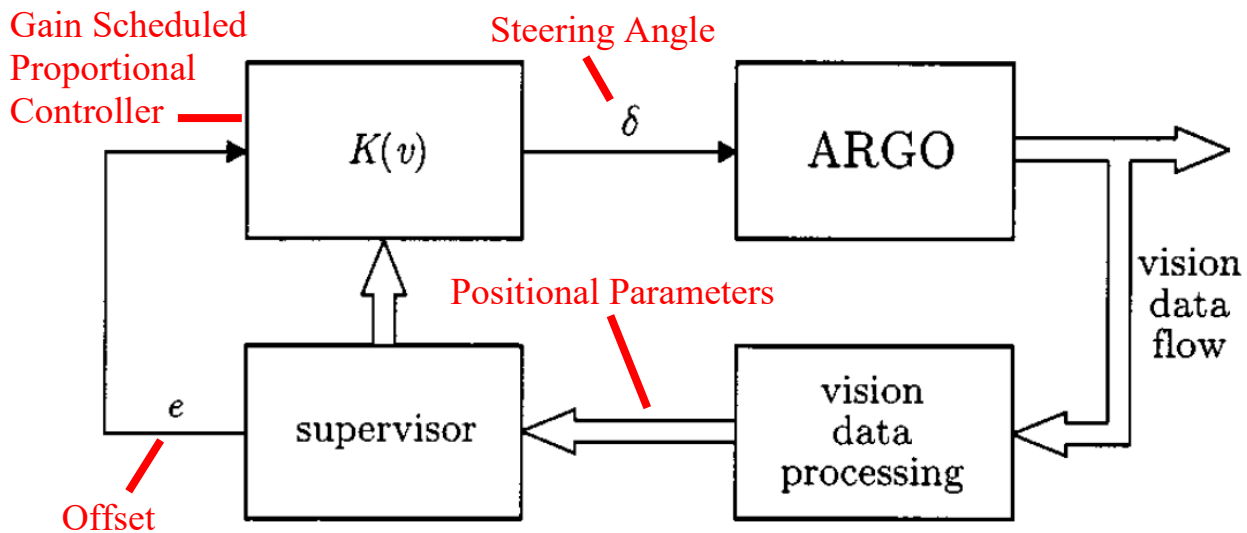
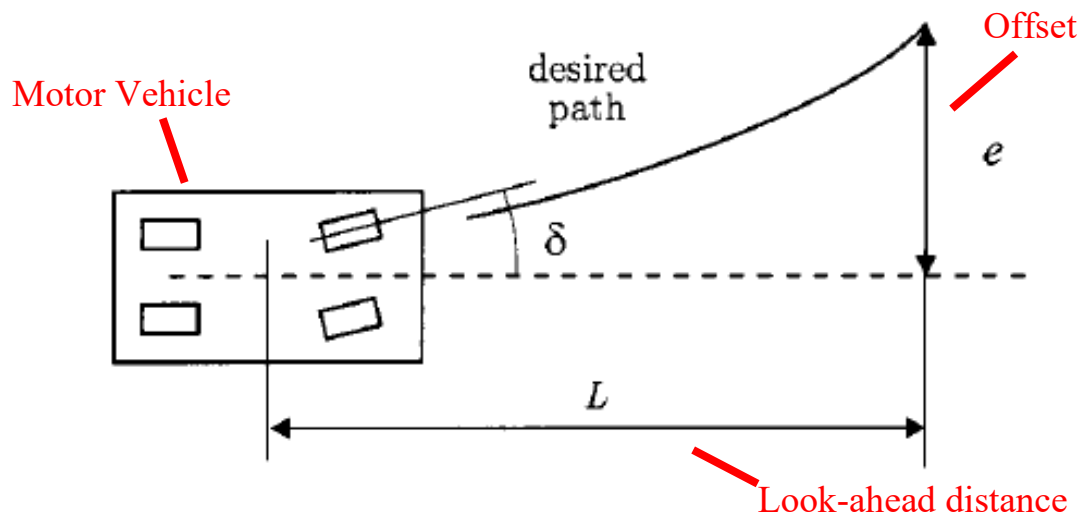


Fig. 20. Control scheme with the gain scheduled proportional controller.

Ex. 1005, Fig. 20 (annotated)

98. More specifically, Broggi details that the steering angle is *calculat[ed]* through the control scheme shown in Figure 20, above. In the vision data processing step, images are acquired and processed through steps including inverse perspective mapping (IPM), lane detection, obstacle detection, and vehicle detection. *See* Ex. 1005, Figs. 19-20, Table I; *see also* Ex. 1005, 173 (“The vision based system reconstructs the road environment and the supervisor uses the results[.]”). The results of the vision data processing are sent to the supervisor, which “uses the results to select the most appropriate gain for the proportional controller and estimate the error signal.” Ex. 1005, 173. Broggi explains that “the offset e existing between the

vehicle heading and the desired path is computed at the look-ahead distance L (see Fig. 21).” Ex. 1005, 173.



Ex. 1005, Fig. 21 (annotated)

99. The output of the vision data system, and more specifically, the relative location and associated distance of the preceding vehicle is utilized by the supervisor, and provided to the gain scheduled proportional controller, which outputs a steering angle to the motor vehicle. *See* Ex. 1005, Fig. 20, *see also* Ex. 1005, Abstract (explaining that Broggi’s methods are implemented on an experimental vehicle “ARGO”). As Fig. 20 of Broggi shows, below, images are acquired as part of a vision data flow. *See* Ex. 1005, Fig. 20; *see also* [1.1] analysis above (discussing acquiring image data). This vision data flow, including the acquired images, are then processed as part of the vision data processing, which extracts information such as positional parameters. *See* Ex. 1005, Fig. 20; *see also*

[1.2] analysis above (discussing extracting). A supervisor uses the information “to select the most appropriate gain for the proportional controller,” and the proportional controller provides the steering angle to the ARGO vehicle system. Ex. 1005, 173; *see* Ex. 1005, Fig. 20.

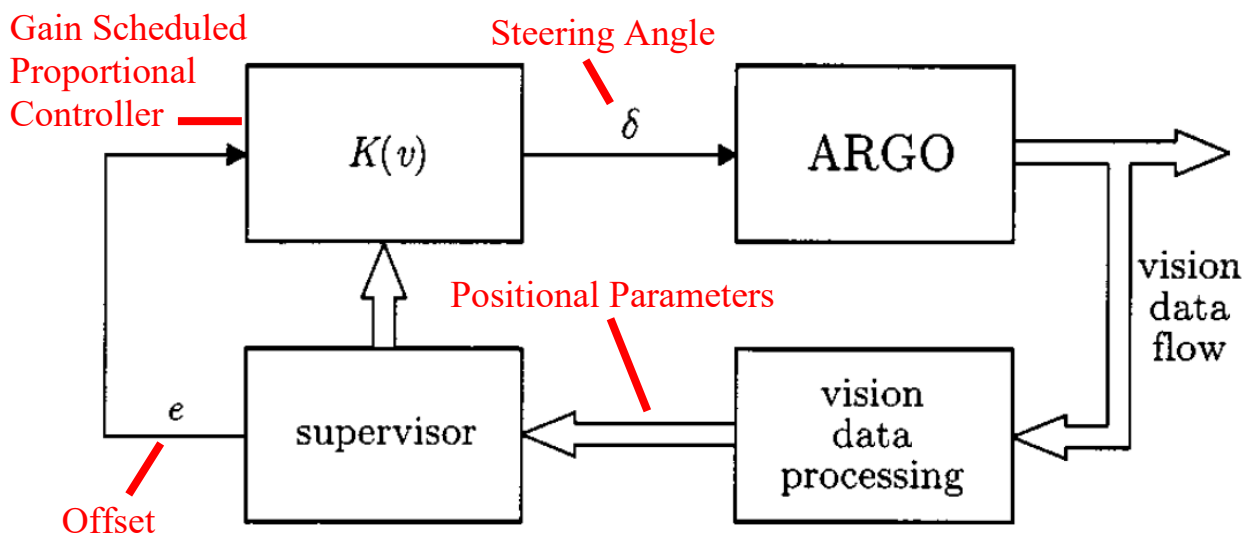


Fig. 20. Control scheme with the gain scheduled proportional controller.

Ex. 1005, Fig. 20 (annotated)

100. **Fourth**, Broggi discloses the steering angle and corresponding desired path are calculated *to assist a subsequent vehicle guidance for at least one of the potential destinations*. When performing the platooning functionality, the motor vehicle of Broggi is automatically steered to follow the preceding vehicle. Ex. 1005, 164. The preceding vehicle is *at least one potential destination* of the vehicle of Broggi because during platooning, “the target point is centered on the preceding

vehicle,” and a desired path extends from the position of the motor vehicle to the target point. Ex. 1005, 174-175, Fig. 21. The steering angle and corresponding desired path *assist[s] a subsequent vehicle guidance for at least one of the potential destinations* because platooning, as described in Broggi, is the “the automatic following of a preceding vehicle” for “an experimental autonomous vehicle equipped with vision systems and automatic steering capability.” Ex. 1005, 164-165. Accordingly, the steering angle and corresponding desired path *assist[s] a subsequent vehicle guidance for one of the potential destinations* by assisting guidance of the vehicle to automatically follow the preceding vehicle. Ex. 1005, 164-165.

101. Thus, Broggi discloses or at least renders obvious *calculating at least one trajectory describing an optimized travel path using the positional parameters* (calculating a steering angle δ for a desired path using the relative location and associated distance of the preceding vehicle) *so as to assist a subsequent vehicle guidance for at least one of the potential destinations* (the steering angle is used for controlling steering of a motor vehicle during platooning to the location of the preceding vehicle).

[1.4.0] wherein the extracting includes: performing an edge detection and edge segmentation on the image data so as to break down the image data into a plurality of edge segments and storing interrelationships of the plurality of edge segments in a mathematical tree structure;

102. Broggi in view of Huttenlocher renders obvious *extracting positional parameters includ[ing] performing an edge detection* (extracting edges, as taught by Broggi and/or Huttenlocher) *and edge segmentation on the image data so as to break down the image data into a plurality of edge segments* (segmenting edges, as detailed by Huttenlocher) *and storing interrelationships of the plurality of edge segments in a mathematical tree structure* (storing the plurality of edge segments in a multi-scale mathematical tree structure based on granularity and relative position) because Broggi and Huttenlocher each disclose performing edge detection, and Huttenlocher further details segmenting edges into a plurality of edge segments and storing the edge segments in a multi-scale mathematical tree structure that indicates the interrelationships between the edge segments based on granularity.

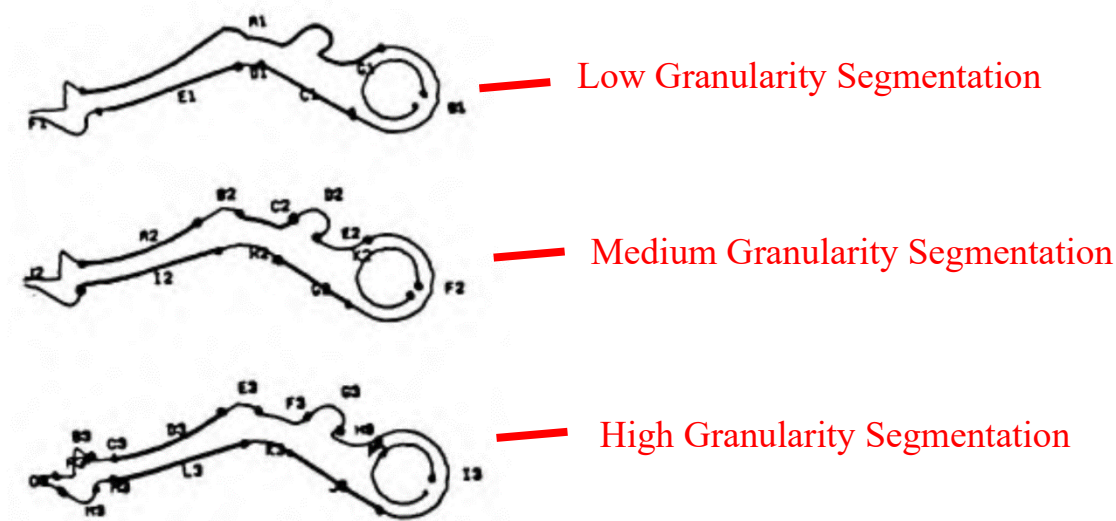
103. As discussed above in the analysis of limitation [1.2], Broggi describes the extraction of positional parameters through the analysis of “a specific region of the image” acquired using a monocular image sequence and/or stereo vision. Ex. 1005, 170; *see also* Ex. 1005, 171 (describing “the search area” for each image). Broggi performs bounding box detection by (1) determining “two corners representing the bottom of the bounding box around the vehicle” and (2) detecting

“the top part of the bounding box, which is looked for in a specific region whose location is again determined by perspective and size constraints.” Ex. 1005, 171. Determining this bounding box in Broggi further includes *performing an edge detection* by extracting edges from the images acquired using a monocular image sequence and/or stereo vision. Ex. 1005, 171 (“**vertical and horizontal edges are extracted** and thresholded, and symmetries are computed in these domains as well.”).

104. Broggi explains that for the vehicle bounding box detection, a “traditional pattern matching technique is used,” but to the extent [1.4.0] is not explicitly taught, it would have been obvious to combine the teachings of Broggi with Huttenlocher. Ex. 1005, 171. In the combination, Broggi implements Huttenlocher’s known pattern matching technique—which segments edges, stores edge segments in a multi-scale tree, and analyzes the edge segments—as part of detecting the location of a preceding vehicle. In the combination, Huttenlocher renders obvious an image analysis matching technique that includes *performing an edge detection and edge segmentation on the image data so as to break down the image data into a plurality of edge segments* (detecting and segmenting edge contours) *and storing interrelationships of the plurality of edge segments in a mathematical tree structure* (storing interrelationships of the plurality of edge segments in a multi-scale mathematical tree structure). Huttenlocher discloses an

image pattern matching technique that includes *performing an edge detection...on the image data* through the use of an edge detector on an input image. More specifically, Huttenlocher teaches a recognition system which “uses edge-based shape features,” where an image “is processed by an edge detector[.]” Ex. 1006, 373; *see also* Ex. 1006, 374 (referencing “the thresholded images extracted by the edge detector” shown in example images). In the combination, Broggi acquires images using a monocular image sequence and/or stereo vision, which are processed using Huttenlocher’s known pattern matching technique, which includes performing edge detection. As noted above in Section VIII.A.4, the combination may utilize Broggi’s edge detection, Huttenlocher’s edge detection, or both Broggi’s edge detection and Huttenlocher’s edge detection..

105. Huttenlocher also discloses an image analysis matching technique that includes *performing ... edge segmentation on the image data so as to break down the image data into a plurality of edge segments* after edge detection by segmenting the edges. Ex. 1006, 373 (“The image is processed by an edge detector [], and the edges are chained together using an eight-way chaining algorithm.”). Figure 3, below, shows “a three-level scale-space curvature segmentation of the edge contours” of a widget as an example of edge segmentation. Ex. 1006, 373.

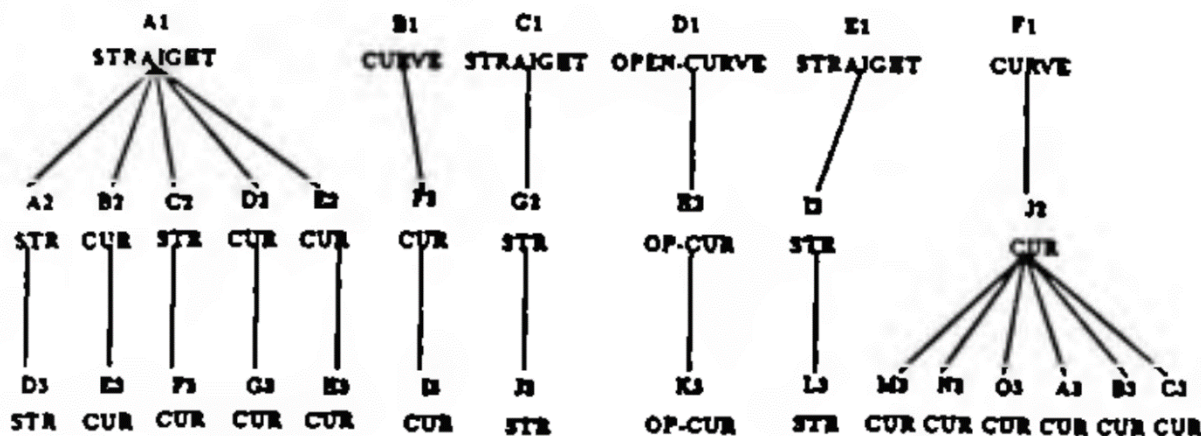


Ex. 1006, Fig. 3 (annotated)

106. In the combination, the images (acquired using Broggi's monocular image sequence and/or stereo vision) are processed using Huttenlocher's known pattern matching technique, which includes performing edge segmentation to break down the image data into a plurality of edge segments.

107. Huttenlocher discloses *storing interrelationships of the plurality of edge segments in a mathematical tree structure* by storing the plurality of edge segments in a multi-scale mathematical tree structure based on granularity. More specifically, Huttenlocher explains that the segmentations, such as the three segmentations in Figure 3 above, “form a (multi-rooted) tree, where each region at a coarse scale corresponds to one or more regions at each finer scale. Figure 4 shows this scale-space segment tree.” Ex. 1006, 373-374, Fig. 4. One such “multi-scale segmentation tree” is represented in Figure 4 of Huttenlocher, below. Figure 4 shows

a tree of the segments of each of the three segmentations of the widget in Figure 3, above, by storing segments in the data structure, with branches corresponding to “one or many segments at the next finer scale” for each stored segment. *See* Ex. 1006, 374, Figs. 3-4. As shown, the tree of Fig. 4 stores the *interrelationships of the plurality of edge segments* based on granularity and relative position. In this way, each level of granularity shown in Figure 3 corresponds to a new layer in the tree shown in Figure 4, with the lowest level of granularity at the top of the tree and each finer level of granularity corresponding to the next layer. *See* Ex. 1006, 374, Figs. 3-4.



Ex. 1006, Fig. 4

108. Huttenlocher’s multi-scale segmentation tree, as reflected in Figure 4 above, is a *mathematical tree structure* because it includes the required features of a mathematical tree structure. Specifically, it is a multi-rooted tree where the subtree

corresponding to each root includes nodes with defined relations represented by branches between nodes such that any two nodes are connected by exactly one path consisting of a sequence of branches. *See* Ex. 1006, Figs. 3-4. Huttenlocher's tree includes multiple levels of relations (i.e., a root node with children nodes, and those children nodes potentially having one or more additional children nodes), which is typical of a mathematical tree structure. *See* Ex. 1006, Figs. 3-4. This is consistent with the description of *a mathematical tree structure* in the specification of the '805 Patent, which explains that "[m]any different proven methods for creating and organizing such a hierarchical tree structure are available to one skilled in the art[.]" Ex. 1001, 4:45-51. Like the '805 Patent, in which "the edges and segments [are] stored in parameters in the branches of the hierarchical tree," (Ex. 1001, 4:65-5:3) Huttenlocher similarly stores segments and parameters, such as "its label" and "the type of segment" in each layer of branches. Ex. 1006, 373-374; *see* Ex. 1006, Figs. 3-4.

109. Thus, Broggi in view of Huttenlocher renders obvious *extracting positional parameters includ[ing] performing an edge detection* (extracting edges, as taught by Broggi and/or Huttenlocher) *and edge segmentation on the image data so as to break down the image data into a plurality of edge segments* (segmenting edges, as detailed by Huttenlocher)) *and storing interrelationships of the plurality of edge segments in a mathematical tree structure* (storing the plurality of edge

segments in a multi-scale mathematical tree structure based on granularity and relative position).

[1.4.1] analyzing the plurality of edge segments for the presence of a geometric object associated with a geometrical form that may at least partially describe a potential destination so as to identify one or more potential geometric objects;

110. Broggi in view of Huttenlocher renders obvious *analyzing the plurality of edge segments for the presence of a geometric object associated with a geometrical form that may at least partially describe a potential destination* (e.g., analyzing coarse level descriptions of edge segments for the presence of a bottom corner of a preceding vehicle associated with a bottom corner of a model vehicle) *so as to identify one or more potential geometric objects* (e.g., identifying potential bottom corners of a preceding vehicle by identifying potentially matching image features). Broggi discloses that pattern matching techniques, such as Huttenlocher's, would be used to identify the presence of a geometric object (e.g., bottom corner of a preceding vehicle) associated with a geometrical form (e.g., the bottom corner of a model vehicle) that at least partially describes a potential destination (e.g., the location of a preceding vehicle). For example, as discussed in the [1.2] and [1.4.0] analysis above, Broggi performs bounding box detection by (1) determining "two corners representing the bottom of the bounding box around the vehicle" and (2) detecting "the top part of the bounding box, which is looked for in a specific region whose location is again determined by perspective and size constraints." Ex. 1005,

171. In this manner, Broggi is analyzing the image data *for the presence of a geometric object* (e.g., bottom corners of a preceding vehicle) *associated with a geometrical form* (e.g., bottom corner of a model vehicle) *that may at least partially describe a potential destination* (e.g., location of a preceding vehicle) *so as to identify one or more potential geometric objects* (e.g., potential bottom corners of a preceding vehicle), but does not explicitly disclose that *a plurality of edge segments* are being analyzed for this purpose. *See* Ex. 1005, 171. In this regard, Broggi explains that for vehicle bounding box detection, a “traditional pattern matching technique is used,” but does not provide details of the pattern matching techniques for implementation within its platooning functionality. Ex. 1005, 171.

111. As discussed in Section VIII.A.4.b, it would have been obvious to combine Broggi and Huttenlocher. In the combination, Broggi implements Huttenlocher’s known pattern matching technique—which analyzes the edge segments for the presence of geometric objects—as part of detecting the location of a preceding vehicle. Huttenlocher describes at least two steps—coarse-scale alignment and fine-scale matching—for its known pattern matching technique. As described in detail below, in the combination, at least the coarse-scale alignment step of Huttenlocher’s pattern matching technique renders obvious [1.4.1], while the fine-scale matching step renders obvious [1.4.2]. Huttenlocher teaches *analyzing the plurality of edge segments for the presence of a geometric object*. Huttenlocher

explains that “coarse level descriptions are [] used to determine which model features can potentially match which image features. These possible matching features form the set of pairs, P , for the alignment algorithm.” Ex. 1006, 374. Features “visible in the image” are used by the alignment algorithm “to align the model with the image.” Ex. 1006, 375. “[T]he position, orientation, and scale of an object are found using a minimal amount of information,” such as the pairs P formed for the alignment algorithm. Ex. 1006, 372. That is, the coarse-scale edge segments are analyzed to identify geometrical features in the image that “potentially match” with corresponding features of a model (bottom corners of a model vehicle) to be detected. Ex. 1006, 374. In this regard, Huttenlocher explains that “[p]oints for use by the alignment algorithm are obtained from the features” based on the types of segments stored in the multi-scale segmentation tree (e.g., curved segments of contour, straight segments, and open-curve segments). Ex. 1006, 373-374. Thus, in the combination, the coarse-level alignment of Huttenlocher (based on analyzing the coarse-scale edge segments of the tree structure) would be utilized to identify a “potential match” for the bottom corners of a preceding vehicle based on shape and spatial arrangement of the edge segments.

112. This is similar to the '805 patent, which looks for geometric shapes corresponding to the typical shapes found in a potential destination. Ex. 1001, 4:51-56, 3:39-43. The flexibility provided by Huttenlocher's pattern matching technique

would be advantageous in vehicle detection given the varying degrees of vehicle designs.

113. Thus, Broggi in view of Huttenlocher renders obvious *analyzing the plurality of edge segments for the presence of a geometric object associated with a geometrical form that may at least partially describe a potential destination* (analyzing coarse level descriptions of edge segments for presence of a bottom corner of a preceding vehicle associated with a bottom corner of a model vehicle) *so as to identify one or more potential geometric objects* (identifying potential bottom corners of a preceding vehicle by identifying potentially matching image features).

[1.4.2] analyzing the one or more potential geometric objects for plausibility using a matching algorithm so as to identify one or more plausible objects;

114. Broggi in view of Huttenlocher renders obvious *analyzing the one or more potential geometric objects for plausibility using a matching algorithm* (scoring one or more geometric objects identified as a “potential match” (from Huttenlocher’s coarse scale alignment step) using Huttenlocher’s fine-scale matching step) *so as to identify one or more plausible objects* (identifying the bottom corners of a possible preceding vehicle) because, as noted in [1.4.1], the fine-scale matching step of Huttenlocher’s matching technique renders obvious [1.4.2].

115. The coarse-scale alignment step is utilized by Huttenlocher to identify features of an image that are a “potential match” for the bottom corners of a

preceding vehicle. Then, for “**scoring how well an alignment matches an image, fine scale model features are used.**” Ex. 1006, 374. That is, fine-scale matching is utilized to score how likely or plausible a “potential match” (from the coarse-scale alignment) is to being an actual match or “plausible object.” Ex. 1006, 374. When the score of Huttenlocher’s fine-scale matching step indicates a “potential match” is a match for a bottom corner of a model vehicle, then the *potential geometric object* is identified as a *plausible object*. This is because, in accordance with Broggi, the *potential geometric object* and, therefore, the *plausible object* (bottom corner of a preceding vehicle), are a match for the bottom corner of a model vehicle, but there is not necessarily a match for the entire preceding vehicle or associated bounding box. *See* Ex. 1005, 170 (discussing “the detection of the two bottom corners of a rectangular bounding box”), 171 (discussing that if “no correct bounding boxes exist,” then “a backtracking approach is used” where a different location is checked such that “a new search for a bounding box is performed”). In this manner, the fine-scale matching step of Huttenlocher’s matching technique is *analyzing the one or more potential geometric for plausibility so as to identify one or more plausible objects*.

116. Further, Huttenlocher’s matching technique is *a matching algorithm*, and thus the fine-scale matching step is also *a matching algorithm* as required by [1.4.2] because each follows a sequence of steps for matching patterns as commonly

known in the art. *See* Ex. 1009, 20 (Microsoft Computer Dictionary defining algorithm as “[a] finite sequence of steps for solving a logical or mathematical problem”); Ex. 1006, 372-373 (explaining how an alignment is scored).

117. Thus, Broggi in view of Huttenlocher renders obvious *analyzing the one or more potential geometric for plausibility using a matching algorithm* (scoring one or more geometric objects identified as a “potential match” (from Huttenlocher’s coarse-scale alignment step) using Huttenlocher’s fine-scale matching step) *so as to identify one or more plausible objects* (identifying the bottom corners of a possible preceding vehicle).

[1.4.3] performing an additional acceptance analysis so as to identify at least one accepted object, the additional acceptance analysis including analyzing a shape of the image formation of each object in the image data based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field; and

118. Broggi alone or in view of Huttenlocher renders obvious *performing an additional acceptance analysis so as to identify at least one accepted object* (e.g., detecting the top part of the bounding box and performing distance refinement to identify a preceding vehicle), *the additional acceptance analysis including analyzing a shape of the image formation of each object in the image data based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field* (e.g., detecting the top part of the bounding box and performing distance refinement to identify the preceding vehicle is done using perspective and size

constraints and a known stereo camera set-up, per Broggi, and/or by analyzing using Huttenlocher's pattern matching technique) because Broggi renders obvious the detection of the top part of the bounding box with distance refinement to identify a preceding vehicle using perspective and size constraints and a known stereo camera set-up, and Huttenlocher discloses an alignment step that accounts for the distortions of shapes in the image formation.⁶

119. Broggi's detecting "**the top part of the bounding box**, which is looked for in a specific region whose location is again **determined by perspective and size constraints**" renders obvious *performing an additional acceptance analysis so as to identify at least one accepted object*. Broggi describes after locating the bottom corners of a vehicle, the "process is followed by the detection of the top part of the

⁶ Regarding the claimed *each object in the image data*, claim 1 of the '805 patent recites "a geometric object," "one or more potential geometric objects," "one or more plausible objects," and "at least one accepted object." The claim is not explicit as to which of these "objects" is being referred to as "each object." However, the claim recites that the analysis is "additional" analysis, so "each object" at least refers to an object for which some analysis was already performed. For the purposes of this declaration, "each object in the image data" is understood to include the claimed "one or more plausible objects."

bounding box[.]” Ex. 1005, 171. This identification of the “top part of the bounding box” corresponds to detecting the top of the preceding vehicle, and is *an additional acceptance analysis* because it is an additional analysis step taken in Broggi as part of its detailed vehicle detection, performed in addition to the locating of the bottom corners of the vehicle. *See* Ex. 1005, 170 (“Finally, the top horizontal limit of the vehicle is searched for, and the preceding vehicle is localized”).

120. Further, detecting the top part of the bounding box is an *acceptance analysis so as to identify at least one accepted object* because if the top of the bounding box/preceding vehicle is unable to be located then the plausible object (e.g., identified as corresponding to the bottom corners of a preceding vehicle as discussed in [1.4.1]-[1.4.2]) is not accepted. *See* Ex. 1005, 171-172. For instance, if “in correspondence to the symmetry maximum no correct bounding boxes exist,” then “a backtracking approach is used” where a different location is checked. Ex. 1005, 171 (“a new search for a bounding box is performed”). On the other hand, if the top part of the vehicle is identified, this completes the bounding box location of the preceding vehicle. *See* Ex. 1005, 1725, Fig. 16 (showing a progression of bounding box detection where “the first symmetry maximum, generated by a building, does not lead to a correct bounding box,” and backtracking is used to “lead[] to the correct detection of the vehicle”).

121. Further, detecting the top part of the bounding box includes *analyzing a shape of the image formation of each object in the image data based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field* because the top of the bounding box is “looked for in a specific region whose location is again **determined by perspective and size constraints.**” Ex. 1005, 171, 172 (describing the “Distance Refinement” step of the “Vehicle Detection Processing Steps”). Further, Broggi explains that, based on these perspective and size constraints, the search area is analyzed to identify a shape corresponding to the top of the vehicle by taking “into account knowledge about **the typical vehicles’ aspect ratio.**” Ex. 1005, 172, Fig. 15. The ’805 patent describes an example *imaging property of the imaging sensor relative to the surrounding field* to include “knowledge of the camera position and camera imaging geometry” Ex. 1001, 7:39-41 (“based on the knowledge of the camera position and camera imaging geometry, objects...would be eliminated...for acceptance analysis”). These are the same types of imaging properties Broggi is taking into account when Broggi describes considering the “perspective effect” of parameters such as “camera orientation, position, optics, etc.” Ex. 1005, 166.

122. The final identification of the position of the preceding vehicle (e.g., additional acceptance analysis) further includes determining a distance to the preceding vehicle. Broggi describes a first estimate of the distance based on the

position of the bounding box with the understanding that “it may assume wrong values since it may happen that the lower part of the vehicle is not correctly detected.” Ex. 1005, 172-173 (“the lower part of the bounding box indicates a wrong distance”). A distance refinement is performed to provide a more accurate distance. The distance refinement utilizes “stereo-based techniques” using two cameras. Together, the detection of the top of the preceding vehicle and the distance refinement of Broggi teach an *additional acceptance analysis* as they are being performed in addition to the detecting of the bottom corners of the preceding vehicle in determining a position of the preceding vehicle.

123. Broggi renders obvious that this analysis would be *based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field*. The ’805 patent describes an example *imaging property of the imaging sensor relative to the surrounding field* including “knowledge of the camera position and camera imaging geometry” Ex. 1001, 7:39-41 (“based on the knowledge of the camera position and camera imaging geometry, objects... would be eliminated... for acceptance analysis”). Broggi’s search for the top part of the preceding vehicle is similarly based on perspective and size constraints that depend on imaging properties of the camera. *See* Ex. 1005, 172 (describing the “Distance Refinement” step of the “Vehicle Detection Processing Steps”). For example, Broggi states the top part of the bounding box “is looked for in a specific region whose location is

again **determined by perspective and size constraints.**” Ex. 1005, 171. A POSITA would have understood that the perspective and size of objects in an image are the result of the relative position and orientation of the camera with respect to *the surrounding field*.

124. The distance refinement step of Broggi is also performed *based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field*. Broggi states “[s]ince the stereo [camera] set-up is known, once the same pattern enclosed into the bounding box is detected on the right image, a simple triangulation allows to measure the vehicle distance.” Ex. 1005, 172. A POSITA would have understood that in order to perform the triangulation of the distance to the vehicle, the relative positions of the cameras in the stereo camera set-up would be accounted for, and thus is *based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field*.

125. Alternatively, Broggi in view of Huttenlocher renders obvious *the additional acceptance analysis including analyzing a shape of the image formation of each object in the image data based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field*. As explained in VIII.A.4.b, a POSITA would have understood that Huttenlocher’s pattern matching technique may be utilized for detecting the bottom corners, the top, or both the bottom corners and the top of the preceding vehicle in Broggi’s platooning method. Ex. 1005,

170-171. This alternative position for [1.4.3] is based on using Huttenlocher's pattern matching technique for detecting both the bottom corners (*see* [1.4.1]-[1.4.2]) and the top of the preceding vehicle [1.4.3]. As detailed above in the analysis of limitations [1.4.1]-[1.4.2], Huttenlocher provides a pattern matching technique that would have been implemented as Broggi's "traditional pattern matching technique" for vehicle detection. *See* [1.4.1]-[1.4.2] analysis above. Huttenlocher's pattern matching technique *analyz[es] a shape of the image formation of each object in the image data* because edge segments are extracted from an acquired image, and those edge segments are analyzed to detect objects within the image. The phrase *shape of the image formation* refers to the how the shape of an object may be distorted as captured in an image, e.g., due to the perspective of the camera. For example, the '805 patent describes a "rectangular geometric form viewed from an elevated location is formed in the image data as a trapezoid that tapers toward the top." Ex. 1001, 3:54-58. In Huttenlocher, the orientation of a shape relative to the imaging sensor, and therefore distortions of the shape in the image formation, are accounted for by the aligning method. For example, Huttenlocher states the alignment method "approximates perspective viewing by orthographic projection plus a scale factor which is proportional to the viewing distance." Ex. 1006, 377. Huttenlocher applies a scale factor to "provide a reasonable approximation of perspective viewing," i.e., considers the known imaging property of the camera

(perspective) relative to the surrounding field. Ex. 1006, 372; *see also* Ex. 1006, 370 (“[T]he problem is not two-dimensional because a flat object positioned in three-space can undergo distortion such as foreshortening when projected into the image plane.... There is also a limited kind of shape distortion caused by projecting a rigid object into the image.”). Huttenlocher’s use of orthographic projection with the scale factor accounts for distortions resulting from the perspective view the camera captures of the surrounding field when performing alignment. Therefore, the *additional acceptance analysis* including detecting the top of the preceding vehicle using the object detection method of Huttenlocher *includ[es] analyzing a shape of the image formation of each object in the image data*.

126. Thus, Broggi alone or in view of Huttenlocher renders obvious *performing an additional acceptance analysis so as to identify at least one accepted object* (detecting the top part of the bounding box and distance refinement to identify a preceding vehicle), *the additional acceptance analysis including analyzing a shape of the image formation of each object in the image data based on knowledge of at least one imaging property of the imaging sensor relative to the surrounding field* (detecting the top part of the bounding box with distance refinement to identify the preceding vehicle is determined using perspective and size constraints and a known stereo camera set-up, per Broggi, and/or by analyzing using Huttenlocher’s pattern matching technique).

[1.4.4] storing at least one accepted object that corresponds to a most proximate destination together with corresponding relative positional data in an object list.

127. Broggi in view of Huttenlocher and Brady renders obvious *storing at least one accepted object that corresponds to a most proximate destination together with corresponding relative positional data* (storing the most proximate preceding vehicle and corresponding location and distance) *in an object list* (stored in a vehicle log) because Brady discloses storing the preceding vehicle and corresponding location and distance in an object list.

128. As discussed in the analysis above, the combination of Broggi and Huttenlocher provides a method of controlling steering of a motor vehicle to follow a preceding vehicle through the implementation of “platooning,” the automatic following of a preceding vehicle. Broggi’s platooning relies in part on obstacle and vehicle detection. And Huttenlocher provides a “traditional pattern matching technique” for vehicle detection that allows Broggi to identify *at least one accepted object*. And as discussed in Section VIII.A.4.c, it would have been obvious to combine Brady with Broggi and Huttenlocher. In the combination, Broggi *stor[es] at least one accepted object that corresponds to a most proximate destination* by storing a preceding vehicle identified using Broggi’s bounding box detection (implementing Huttenlocher’s pattern matching technique). *See [1.4.3] analysis above.* The identified preceding vehicle *corresponds to a most proximate destination*

because the current location of the immediately preceding vehicle is the next or most proximate destination of the vehicle during platooning. Brady provides details regarding the storage of data in object lists in the same context of “classifying and tracking vehicles” captured “in real-time,” like the platooning of Broggi-Huttenlocher. Ex. 1007, 3:59-62, 11:21-25; *see also* Ex. 1005, 172 (discussing “tracking an already found” vehicle).

129. Brady describes a method for identifying and tracking vehicles in a roadway scene. Ex. 1007, Abstract. Brady discloses storing identified vehicles with corresponding positional data in an object list. Ex. 1007, 11:21-25. For example, the system of Brady “maintains oversight of the scene, including **keeping a vehicle log** 102 of all vehicles currently within the scene, including vehicles’ associated track histories, inertial history 104 of the scene... and potential future track positions....” Ex. 1007, 11:21-25. Thus, in the combination, vehicles detected by Broggi, including at least the identified preceding vehicle (a name or an identifier associated with the identified preceding vehicle), are *stored...in an object list*, such as a vehicle log, per Brady. *See* Ex. 1007, 11:21-25; *see also* Ex. 1005, 166 (discussing “obstacle detection,” “lane detection,” and “localization and tracking of a target vehicle”), 164 (“Vehicles are localized and tracked”).

130. Further, the identified preceding vehicle would be stored in the list *together with corresponding relative positional data*, such as a relative location of

the preceding vehicle and an associated distance to the vehicle following, because Brady suggests logging positional information related to detected vehicles. *See* Ex. 1007, 11:21-25 (noting that a vehicle log includes “vehicles’ associated track histories, inertial history 104 of the scene...and potential future track positions”); *see also* [1.2] analysis above. The track histories of the vehicles include the positional data of the vehicles, and as discussed in [1.2] analysis above, Broggi utilizes the relative position of the preceding vehicle during platooning. *See* Ex. 1007, 11:21-25; *see also* [1.2] analysis above. In this regard, Broggi’s method would reference and update the object list over time (updating the information to reflect the current position of the preceding vehicle relative to the vehicle and/or keep a log of past positions) to perform the functions associated with platooning, such as determining a desired path and associated steering angle. Ex. 1005, 173, Fig. 21

131. Thus, Broggi in view of Huttenlocher and Brady renders obvious *storing at least one accepted object that corresponds to a most proximate destination together with corresponding relative positional data* (storing the most proximate preceding vehicle and corresponding location and distance) *in an object list* (stored in a vehicle log).

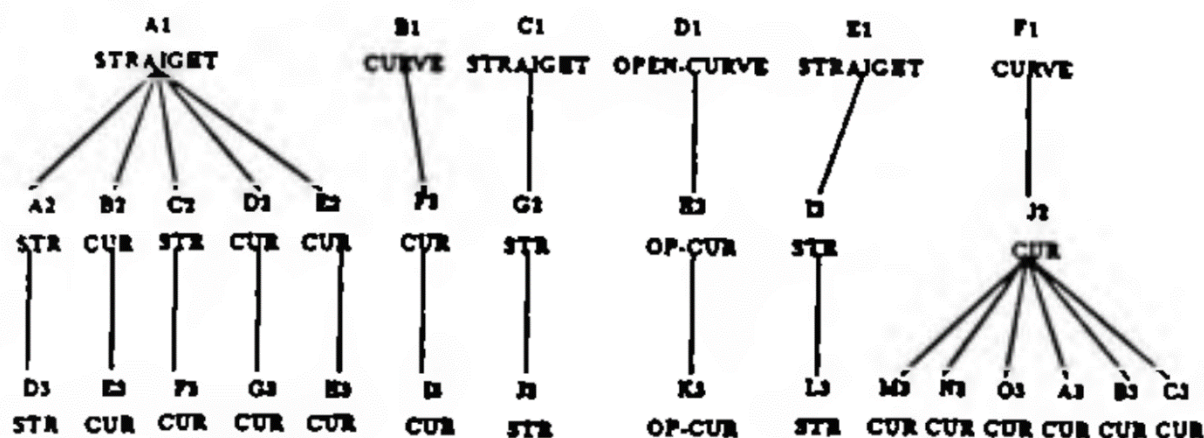
3. Claim 2

[2.0] The method as recited in claim 1, further comprising processing the mathematical tree structure using a tree traversal algorithm.

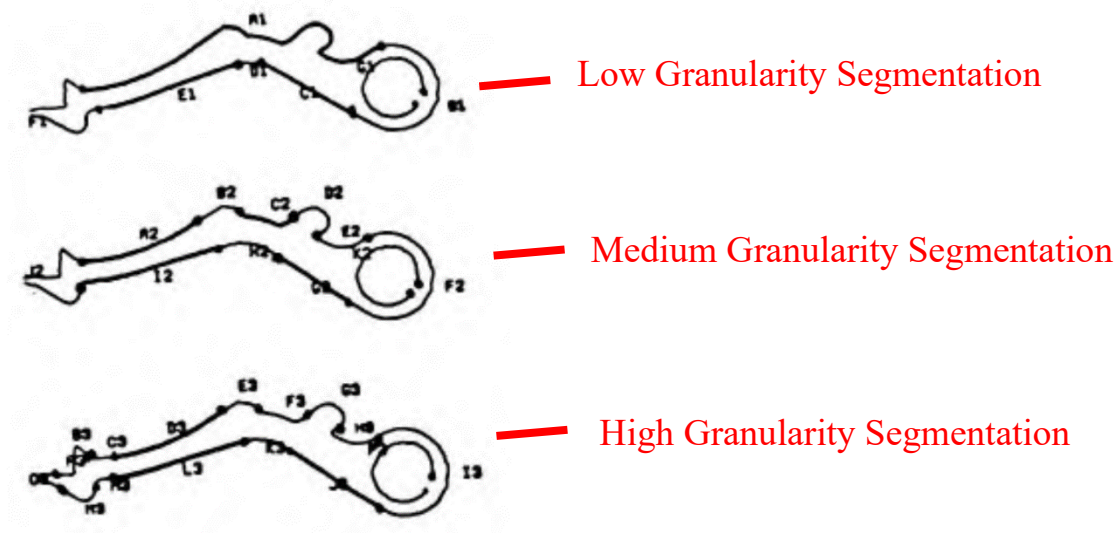
132. Broggi in view of Huttenlocher renders obvious *processing the mathematical tree structure using a tree traversal algorithm* (analyzing multi-scale mathematical tree structure by analyzing coarse then fine features as stored in the tree structure) because Huttenlocher discloses analyzing a multi-scale mathematical tree structure by analyzing coarse-scale then fine-scale features stored in the tree structure as part of the coarse-scale alignment and fine-scale matching discussed in [1.4.1]-[1.4.2] analysis above.

133. A POSITA would have understood that starting with the “coarse level descriptions” of the tree structure and then using the corresponding “fine scale model features” represents a traversal of the tree structure using a tree traversal algorithm because it starts at one end of the tree (top of Fig. 4) and proceeds towards another end of the tree (bottom of Fig. 4). *See* Ex. 1006, 374, Fig. 4. Further, Huttenlocher explains that “coarse level descriptions are [] used to determine which model features can potentially match which image features. These possible matching features form the set of pairs, *P*, for the alignment algorithm.” Ex. 1006, 374. Then fine-scale matching is utilized to score how likely or plausible a “potential match” (from the coarse-scale alignment) is to being an actual match for an object. Ex.1006,

374. This approach is like the '805 patent, which similarly describes a tree traversal algorithm where “based on the knowledge of the typical geometric shape of a destination, the edges and segments stored in parameters in the branches of the hierarchical tree are analyzed to check if they are able to be pieced together to form geometric objects which describe suitable, typical destinations.” Ex. 1001, 4:65-5:3.



Ex. 1006, Fig. 4



Ex. 1006, Fig. 3 (annotated)

134. Thus, Broggi in view of Huttenlocher renders obvious *processing the mathematical tree structure using a tree traversal algorithm* (analyzing multi-scale mathematical tree structure by analyzing coarse then fine features as stored in the tree structure).

4. Claim 9

[9.0] The method as recited in claim 1, further comprising performing an at least semi-automatic vehicle guidance to the most proximate destination using the at least one trajectory.

135. Broggi discloses or at least renders obvious *performing an at least semi-automatic vehicle guidance to the most proximate destination using the at least one trajectory* (automatically controlling steering of the motor vehicle to follow a preceding vehicle using a steering angle for a desired path) because Broggi discloses

that its motor vehicle automatically follows the preceding vehicle during platooning using a steering angle for a desired path to the preceding vehicle's location.

136. Broggi describes “an experimental autonomous vehicle equipped with vision systems and automatic steering capability.” Ex. 1005, 165. Broggi explains that there are varying levels of system intervention for its described vehicle, including manual driving, supervised driving, and automatic steering. Ex. 1005, 166. Further, Broggi explains that automatic steering has two different functionalities, including road following—“the automatic movement of the vehicle inside the lane”— and platooning—“[t]he automatic following of the preceding vehicle[.]” Ex. 1005, 166. Broggi's platooning is *at least semi-automatic vehicle guidance* because platooning is “automatic following,” and the '805 patent makes clear that automatic vehicle guidance is *at least semi-automatic*, and indeed, more than semi-automatic. Ex. 1005, 166; *see* Ex. 1001, 6:53-56 (“the vehicle guidance may subsequently be carried out automatically or at least semi-automatically”).

137. Further, as discussed above in the analysis of limitation [1.3], Broggi calculates a steering angle δ for a desired path using the relative location and associated distance of the preceding vehicle, where the steering angle is used for controlling steering of a motor vehicle during platooning to the location of the preceding vehicle (e.g. to the current location of the preceding vehicle). *See* [1.3] analysis above. In this way, Broggi's platooning is the automatic guidance of an

autonomous vehicle to a target (the preceding vehicle) following a steering angle δ for a desired path to the preceding vehicle. See [1.3] analysis above. Full automatic guidance of an autonomous vehicle in this manner is *at least semi-automatic vehicle guidance*.

138. Thus, Broggi discloses or at least renders obvious *performing an at least semi-automatic vehicle guidance to the most proximate destination using the at least one trajectory* (automatically controlling steering of the motor vehicle to follow a preceding vehicle using a steering angle for a desired path).

5. Claim 10

[10.0] The method as recited in claim 9, further comprising using at least one of an audible and a visual signaling during the vehicle guidance to assist a driver of the vehicle in observing the trajectory.

139. Broggi discloses or at least renders obvious *using at least one of an audible* (acoustic signaling) *and a visual signaling* (optical signals) *during the vehicle guidance to assist a driver of the vehicle in observing the trajectory* (to provide a warning or indication related to the path of travel during platooning) because Broggi discloses the use of acoustic signaling and optical signals during platooning to provide a warning or indication related to the path of travel to the driver.

140. Broggi explains that its autonomous vehicle has system functionalities where “the driver can select the level of system intervention.” Ex. 1005, 166. The

vehicle includes several output devices, including “acoustical (stereo loudspeakers) and optical (LED-based control panel) devices[.]” Ex. 1005, 165. These devices “are used to issue warnings to the driver in case dangerous conditions are detected[.]” Ex. 1005, 165. More specifically, an “LED row on the control panel encodes the vehicle position within the lane, while the right or left speakers warn in case the vehicle is approaching too much to the right or left lane marking.” Ex. 1005, 166. In this way, Broggi renders obvious *using at least one of an audible* (stereo loudspeakers to provide lane warnings) *and a visual signaling* (an LED row reflecting the vehicle position in the lane) while the vehicle is driving. Further, while primarily discussed in the context of supervised driving, Broggi does not limit the implementation of such safety measures to just the supervised driving mode. Indeed, Broggi discusses that these output devices are installed in the vehicle “to issue warnings to the driver in case dangerous conditions are detected” when discussing the design of the vehicle, in conjunction with the device which “provides autonomous steering capabilities.” Ex. 1005, 165-166. Thus, Broggi renders obvious that these warnings would be used *during the vehicle guidance to assist a driver of the vehicle in observing the trajectory* because they are not tied to a specific driving mode of the vehicle, but instead to the operation of the vehicle and detection of dangerous conditions. *See* Ex. 1005, 165.

141. A POSITA would have been motivated, and found it obvious, to use the known approach of audio and visual indicators used in supervised driving mode for providing the same information to a “driver” while in automatic steering mode. Providing the indications while in automatic steering mode would provide useful information that may allow a driver to know if they should take control of the vehicle due to a failure in the system. For example, an auditory warning that the vehicle is too far to one side of the lane may indicate the driver needs to take control to avoid the vehicle leaving the road. This could happen, for example, if the preceding vehicle were to unexpectedly leave the road.

142. Thus, Broggi discloses or at least renders obvious *using at least one of an audible* (acoustic signaling) *and a visual signaling* (optical signals) *during the vehicle guidance to assist a driver of the vehicle in observing the trajectory* (to provide a warning or indication related to the path of travel during platooning).

B. Ground 2: Claims 6-8 and 11 are rendered obvious over Broggi in view of Huttenlocher, Brady, and Bertozzi

143. It is my opinion that the combined teachings of Broggi, Huttenlocher, Brady, and Bertozzi disclose or render obvious, to a POSITA, the subject matter of each and every element of claims 6-8 and 11 of the '805 Patent.

1. Reasons to Combine Broggi, Huttenlocher, and Brady

a) Analogous Art

144. Bertozzi is analogous art to the '805 patent because it is in the same field of endeavor: image processing and the detection of objects (e.g., vehicles) in images, including vehicle detection in images for automated driving. Ex.1001, 1:6-9; Ex.1008, 163 (“The vision system”), 171, 174 (“Automatic Driving” functionality). Bertozzi is reasonably pertinent to a particular problem addressed by the '805 patent, namely, automated control of a vehicle based on image analysis. Ex.1001, 6:53-56; Ex.1008, 171, 174.

b) Motivation to Combine Broggi, Huttenlocher, Brady, and Bertozzi

145. A POSITA would have been motivated and found it obvious to use additional configuration details of the autonomous vehicle described in Bertozzi with the Broggi-Huttenlocher-Brady combination that performs vehicle platooning because a teaching, suggestion, or motivation in the prior art (Broggi and Bertozzi both describe the same autonomous vehicle) would have led one of ordinary skill to combine the references (the platooning method of Broggi-Huttenlocher-Brady with Bertozzi's further vehicle configuration details). Ex.1005, 164; Ex.1008, 161.

146. Likewise, a POSITA would have been motivated to implement Bertozzi's additional configuration details as part of platooning—as taught by the

combination of Broggi, Huttenlocher, and Brady—because doing so would have been the combination of prior art elements (the platooning method of Broggi-Huttenlocher-Brady and Bertozzi’s vehicle configuration) according to known methods to yield predictable results (using Bertozzi’s vehicle configuration in platooning). Bertozzi provides details regarding the configuration of an ARGO vehicle that a POSITA would have looked for to implement and improve Broggi’s disclosed platooning. Further, Bertozzi details safety systems that a POSITA would have recognized provided several benefits to Broggi’s platooning, including at least protecting the vehicle and passengers, improving the user experience (e.g., by avoiding sudden or dangerous movements), and avoiding accidents.

147. In the combination, a POSITA would merely be implementing details of Broggi’s vehicle that were used and/or contemplated, but not explicitly detailed in Broggi. For example, a vehicle performing platooning—per Broggi-Huttenlocher-Brady—would utilize the control system “emergency feature” described in Bertozzi to “avoid sudden and therefore dangerous movements of the steering wheel” based on vehicle speed. Ex.1008, 171 (“at a low speed, two consecutive positions of the steering wheel can be quite different; on the other hand, when driving at high speed, only small steering wheel movements are permitted.”). Further, in the combination, the autonomous vehicle would use its display to “display[] the results of the process on a 6” on-board color monitor.” Ex.1008, 168-169; Ex.1005, 165 (ARGO vehicle

includes “a color monitor”). For example, the monitor would “present[] a bi-dimensional reconstruction of the road scene” with data resulting from the vision data flow, such as the location of the preceding vehicle, the desired path and associated trajectory to the location of the preceding vehicle, and “the position of obstacles.” Ex.1008, 168-169.

148. A POSITA would have had a reasonable expectation of success in using the configuration details of Bertozzi—limiting steering wheel movements based on vehicle speed and outputting processing results to an on-board monitor—with the Broggi-Huttenlocher-Brady combination because Bertozzi describes using these configuration details in the same autonomous vehicle described in Broggi. *See* Ex.1005, 164; Ex.1008, 161. Further, a POSITA would have recognized that the benefits associated with the configuration details described in Bertozzi (e.g., avoiding sudden and/or dangerous movements as well as being provided a visual indication of the data resulting from the vision data flow) would have been equally applicable and beneficial in the context of the Broggi-Huttenlocher-Brady combination. Accordingly, a POSITA had a reasonable expectation of success in combining Bertozzi with Broggi-Huttenlocher-Brady.

2. Claim 6

[6.0] The method as recited in claim 1, wherein the calculation of the at least one trajectory includes considering a steering property and a capability of the motor vehicle.

149. Broggi in view of Bertozzi discloses or at least renders obvious *the calculation of the at least one trajectory* (calculating a steering angle δ for a desired path) *includes considering a steering property and a capability of the motor vehicle* (the steering angle calculation takes into consideration the current position of the steering wheel and permitted degree of steering wheel movement at a given speed) because Bertozzi discloses considering the current position of the steering wheel and permitted degree of steering wheel movement at a given speed when calculating a steering angle in an ARGO vehicle such as Broggi's motor vehicle.

150. As described in the [1.3] analysis, Broggi discloses *calculating at least one trajectory describing an optimized travel path* by calculating a steering angle δ for a desired path. Figure 20, below, reflects how the data collected from image acquisition and processing, including the vehicle detection data such as a relative location and associated distance of the preceding vehicle, is passed to a supervisor. *See* Ex. 1005, 173, Fig. 20. “[T]he supervisor uses the results to select the most appropriate gain for the proportional controller and estimate the error signal.” Ex. 1005, 173. “The command steering angle δ is obtained with a variable gain proportional controller.” Ex. 1005, 173; *see also* Ex. 1005, 164-165 (“The steering

control for the Platooning functionality is based on a gain scheduled proportional controller whose error input is evaluated using the estimated position of the preceding vehicle.”).

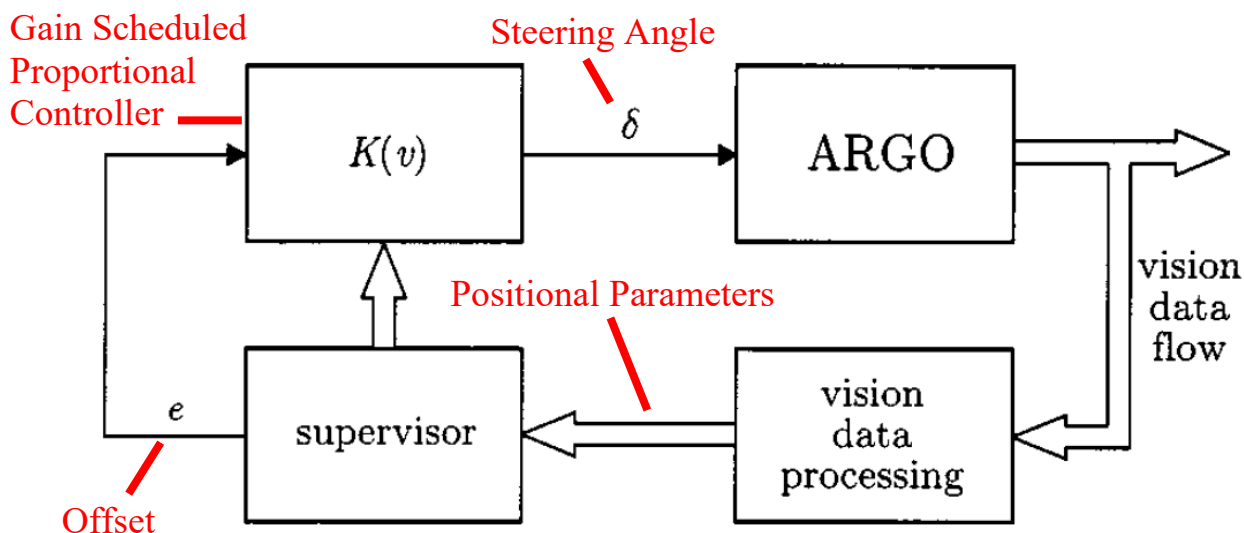


Fig. 20. Control scheme with the gain scheduled proportional controller.

Ex. 1005, Fig. 20 (annotated)

151. Bertozzi provides further details regarding the control system of an ARGO vehicle, such as the motor vehicle described in Broggi. *See generally* Ex. 1008, 161-175. Bertozzi explains that “[o]nce the road geometry ahead of the vehicle has been recovered, a software module is used to compute signals to be issued to the steering wheel actuator. More precisely, starting from the knowledge regarding road geometry and vehicle speed, this module determines the vehicle yaw and computes the position that the vehicle will assume within a given time

interval[.]” Ex. 1008, 171. As noted immediately above, Broggi uses a supervisor and variable gain proportional controller as its software modules to determine a steering angle and control navigation. *See* Ex. 1005, 173, Fig. 20.

152. Bertozzi seeks to “avoid sudden and therefore dangerous movements of the steering wheel” while driving. Ex. 1008, 171. Accordingly, “[e]ach new position...is compared to the current position and processed through a limiting filter, whose threshold depends on vehicle speed. In other words, when the vehicle is moving at a low speed, two consecutive positions of the steering wheel can be quite different; on the other hand, when driving at a high speed, only small steering wheel movements are permitted.” Ex. 1008, 171.

153. As discussed in Section VIII.B.2.b, it would have been obvious to combine Bertozzi with Broggi-Huttenlocher-Brady. In the combination, a vehicle performing platooning—per Broggi-Huttenlocher-Brady—would consider a steering property (current position of the steering wheel) and a capability of the motor vehicle (amount of steering change allowed at a given speed) when determining a steering angle for a desired path to the preceding vehicle. This would ensure that sudden or dangerous movements are avoided, per Bertozzi. *See* Ex. 1008, 171.

154. Thus, Broggi in view of Bertozzi renders obvious *the calculation of the at least one trajectory* (calculating a steering angle δ for a desired path) *includes*

considering a steering property and a capability of the motor vehicle (the steering angle calculation takes into consideration the current position of the steering wheel and permitted degree of steering wheel movement at a given speed).

3. Claim 7

[7.0] The method as recited in claim 6, further comprising rejecting a potential destination that is not reachable given the steering property and capability of the motor vehicle.

155. Broggi in view of Bertozzi renders obvious *rejecting a potential destination that is not reachable given the steering property and capability of the motor vehicle* (rejecting a current location of a preceding vehicle as unreachable given the current position of the steering wheel and the amount of steering change allowed at a given speed) because Broggi in view of Bertozzi renders obvious rejecting the current location of a preceding vehicle that cannot be reached due to steering angle limitations and safety considerations.

156. As discussed above in the analysis of claim 6, it would have been obvious to a POSITA that a vehicle performing platooning, per Broggi and as modified in view of Huttenlocher and Brady, would further contemplate, per Bertozzi, the current position of the steering wheel (*a steering property*) and the permitted degree of steering wheel movement at a given speed (*a capability of the motor vehicle*) when determining a steering angle for a desired path to the preceding vehicle. This would ensure that sudden or dangerous movements are avoided, per

Bertozzi. *See* Ex. 1008, 171. For this same reason, it would have been obvious to *reject[] a potential destination that is not reachable given the steering property and capability of the motor vehicle*, such as a preceding vehicle that cannot be reached due to steering angle limitations, as it would not be sensical to calculate a trajectory to a preceding vehicle that violates the steering angle limitations. Because the system would be unable to calculate a desired path to the current location of the preceding vehicle given the safety constraints, the system would reject the potential destination (current location of the preceding vehicle) as not being reachable given the steering property and capability of the vehicle (current position of the steering wheel and amount of steering change allowed at a given speed). Further, it would have been obvious in such situations to provide an audible and/or visual warning to indicate the rejection via Broggi's "acoustical (stereo loudspeakers) and optical (LED-based control panel) devices [] used to issue warnings to the driver in case dangerous conditions are detected" and/or via the "on-board color monitor." Ex. 1005, 165; *see also* Ground 1, claim [10.0].

157. Thus, Broggi in view of Bertozzi renders obvious *rejecting a potential destination that is not reachable given the steering property and capability of the motor vehicle* (rejecting a current location of a preceding vehicle as unreachable given the current position of the steering wheel and the amount of steering change allowed at a given speed).

4. Claim 8

[8.0] The method as recited in claim 1, further comprising informing a driver of the motor vehicle about a position of at least one potential destination and about the at least one trajectory.

158. Broggi in view of Bertozzi renders obvious *informing a driver of the motor vehicle about a position of at least one potential destination and about the at least one trajectory* (providing information via output devices, such as the on-board color monitor, of the current location of the preceding vehicle and the trajectory of the desired path to the current location of the preceding vehicle) because Broggi in view of Bertozzi renders obvious providing information via output devices regarding the path of the vehicle and the position of the preceding vehicle during operation of an ARGO vehicle.

159. As discussed in VIII.B.2.b, in the combination the autonomous vehicle would use its “on-board color monitor” to “present[] a bi-dimensional reconstruction of the road scene” including the location of the preceding vehicle, the desired path to the location of the preceding vehicle, and the position of obstacles. Ex. 1005, Fig. 20-22; Ex. 1008, 168-169. In this manner, the system informs the driver of the current location of the preceding vehicle in the platoon (i.e., a position of at least one potential destination) and the trajectory of the desired path following the preceding vehicle to its current location (i.e., at least one trajectory). Ex. 1005, Fig. 20-22; Ex. 1008, 168-169.

160. Thus, Broggi in view of Bertozzi renders obvious *informing a driver of the motor vehicle* (e.g., displaying on a monitor in the vehicle in view of the driver) *about a position of at least one potential destination* (e.g., a bounding box location) *and about the at least one trajectory* (e.g., a steering angle).

5. Claim 11

[11.0] The method as recited in claim 9, further comprising: continuously monitoring a position of the stored at least one accepted object during the vehicle guidance.

161. Broggi discloses or at least renders obvious *continuously monitoring a position of the stored at least one accepted object* (tracking the position of vehicles detected and stored per Brady) *during the vehicle guidance* (vehicle guidance during platooning) because Broggi in view of Brady renders obvious continuously tracking the position of the detected preceding vehicles stored during platooning.

162. Broggi explains that during platooning, images are continuously acquired and then processed through steps including inverse perspective mapping (IPM), lane detection, obstacle detection, and vehicle detection, as reflected in Figure 19 and Table I, below:

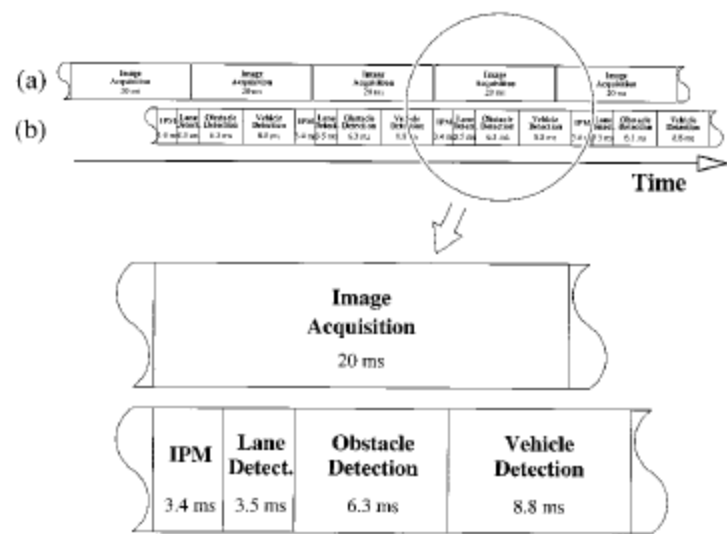


Fig. 19. Image acquisition (a) and processing (b) performance.

Ex. 1005, Fig. 19

TABLE I
TIMINGS OF PROCESSING STEPS

	Pentium 200MMX	Pentium II 450MMX	Speedup
IPM	9.9 ms	3.4 ms	2.9
Lane Detection	14.4 ms	3.5 ms	4.1
Obstacle Detection	17.5 ms	6.3 ms	2.7
Vehicle Tracking	24.8 ms	8.8 ms	2.8
Vehicle Detection	47.6 ms	19.9 ms	2.4

Ex. 1005, Table I

163. Broggi’s vehicle system “is able to continuously capture images into a circular buffer in main memory, therefore, not requiring a synchronization with the processing,” as reflected in Figure 19, above. Ex.1005, 173. This capture, processing, and vehicle operation is further reflected in Figure 20, below:

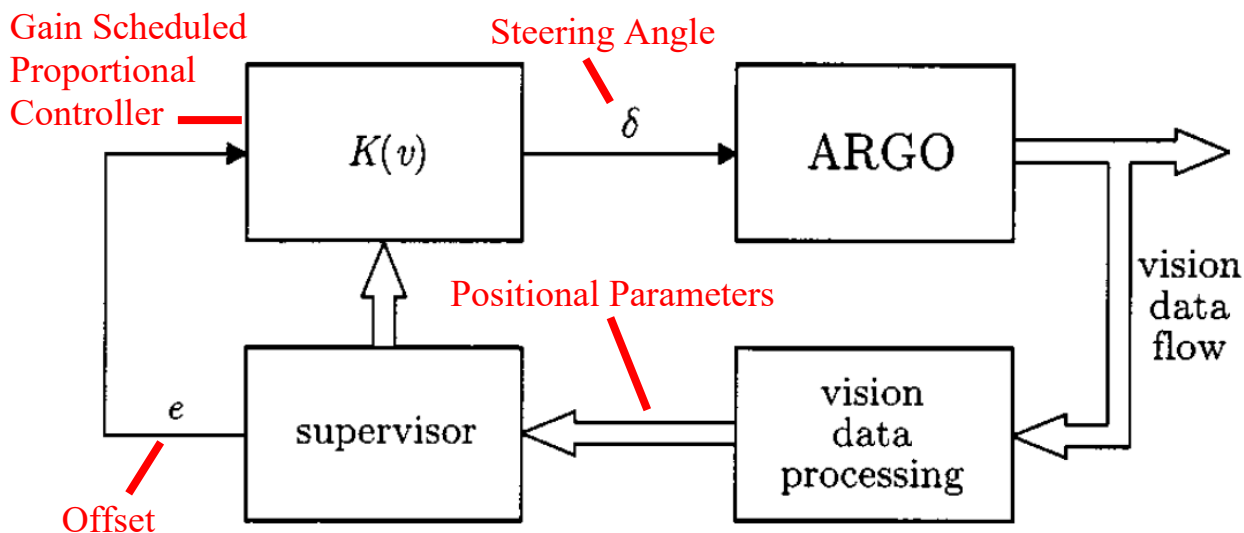


Fig. 20. Control scheme with the gain scheduled proportional controller.

Ex. 1005, Fig. 20 (annotated)

164. The refresh rate of the cameras imposes a sampling time on the vision system. Ex. 1005, 174 (“The controller sampling time is imposed by the vision system....”). Broggi discloses that “50 pairs of single field images are processed every second.” Ex. 1005, 165. As described in the [1.4.3]-[1.4.4] analysis, the claimed at least one accepted object is an identified vehicle whose location is defined by the bounding box. A POSITA would have understood that the presence of the vision data processing within a control loop with a certain refresh rate represents *continuous monitoring* of the location of a preceding vehicle, as the constant refreshing of the image data in the control loop ensures that the position of the preceding vehicle is kept current, and as a result, the steering angle and associated

desired path are continuously adjusted according to the latest position of the preceding vehicle.

165. Thus, Broggi discloses or at least renders obvious *continuously monitoring a position of the stored at least one accepted object* (tracking the position of vehicles detected and stored per Brady) *during the vehicle guidance* (during platooning).

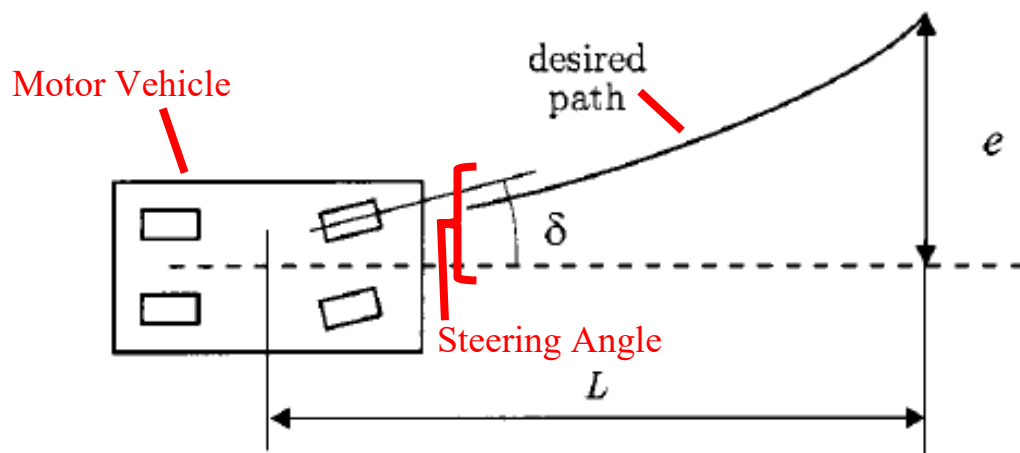
[11.1] selecting a new most proximate destination went the most proximate destination is no longer easily reachable⁷

166. Broggi in view of Bertozzi renders obvious *selecting a new most proximate destination* (selecting a new location of the preceding vehicle) *[when] the most proximate destination is no longer easily reachable* (when the stored location of the current preceding vehicle is reached by the motor vehicle) because Broggi in view of Bertozzi renders obvious selecting a new location of the preceding vehicle

⁷ Claim 11 issued with the language *selecting a new most proximate destination went the most proximate destination is no longer easily reachable*. For purposes of this declaration, I will interpret this claim as reciting *selecting a new most proximate destination [when] the most proximate destination is no longer easily reachable*.

when a previous location of the preceding vehicle is no longer reachable by the motor vehicle.

167. As discussed above, Broggi describes “an experimental autonomous vehicle equipped with vision systems and automatic steering capability.” Ex. 1005, 165. During the course of platooning, Broggi’s motor vehicle calculates a steering angle δ and corresponding desired path, as reflected in Figure 21, below:



Ex. 1005, Fig. 21 (annotated)

168. Broggi in view of Bertozzi renders obvious selecting a new location of a preceding vehicle when a previous location is no longer reachable by the motor vehicle in at least three ways.

169. **First**, as discussed in the [7.0] analysis, Broggi in view of Bertozzi renders obvious rejecting a current location of the preceding vehicle as unreachable based on the current position of the steering wheel and the amount of steering change

allowed at a given speed. When the current location of the preceding vehicle (i.e., the current most proximate destination) is rejected for no longer being reachable, the system would select a new location (i.e., a new most proximate destination) for the vehicle because as discussed in the [11.0] analysis, Broggi is continuously capturing and processing images, and updating vehicle operation. The new location would be a location that the vehicle can reach given the current location of the vehicle, the current position of the steering wheel, and the amount of steering change allowed at the given speed of the vehicle. For example, in some instances, movement of the preceding vehicle will result in the preceding vehicle returning to a location relative to the vehicle that is reachable given the steering safety constraints. That is, the new location of the preceding vehicle is reachable from the current location of the vehicle based on the current position of the steering wheel and the amount of steering change allowed at the current speed of the vehicle. In this manner, Broggi in view of Bertozzi *select[s] a new most proximate destination* (new location of the preceding vehicle) *[when] the most proximate destination is no longer easily reachable* (previous current location of the preceding vehicle is no longer reachable due to steering safety constraints).

170. **Second**, as discussed in the [11.0] analysis, during platooning Broggi continuously tracks and updates the current position of the preceding vehicle and adjusts the steering angle and associated desired path to follow the preceding

vehicle. As Broggi's motor vehicle passes each current location of the preceding vehicle (i.e., the *most proximate destination*), that location is no longer easily reachable because Broggi's motor vehicle is beyond the location and traveling away from the location. As Broggi's motor vehicle passes the previous current locations of the preceding vehicle (*[when] the most proximate destination is no longer easily reachable*), the system selects a new current location of the preceding vehicle (*selecting a new most proximate destination*) based on the steering safety constraints of Bertozzi discussed in the [6.0] and [7.0] analysis.

171. **Third**, it would have been obvious for Broggi to select a new most proximate destination (location of a new preceding vehicle) when the current most proximate destination (current location of a previous preceding vehicle) is no longer easily reachable due to the presence of a new immediately preceding vehicle for one or more reasons (previous preceding vehicle pulls off the road or a new vehicle pulls in between the previous preceding vehicle and the motor vehicle). In such instances, the new preceding vehicle would become the preceding vehicle in Broggi's platooning and the corresponding current location of the new preceding vehicle (i.e., *a new most proximate destination*) would be selected taking into consideration the current location of the vehicle and the steering safety constraints of Bertozzi.

172. Thus, Broggi in view of Bertozzi renders obvious *selecting a new most proximate destination* (selecting a new location of the preceding vehicle) *[when] the*

most proximate destination is no longer easily reachable (when the stored location of the current preceding vehicle is reached by the motor vehicle).

[11.2] wherein the new most proximate destination is selected based on an active position of the motor vehicle and in determining the at least one accepted object that is best reachable, considering a steering properties and a capability of the vehicle; and

173. Broggi in view of Bertozzi renders obvious *the new most proximate destination* (the new current location of a preceding vehicle) *is selected based on an active position of the motor vehicle* (the current position of the vehicle during platooning) *and in determining the at least one accepted object that is best reachable considering a steering properties and a capability of the vehicle* (determining the preceding vehicle best reachable taking into consideration the current position of the steering wheel and permitted degree of steering wheel movement at the given speed of the vehicle).

174. As discussed in the [11.1] analysis, Broggi in view of Bertozzi renders obvious selecting a new location of a preceding vehicle when a previous location is no longer reachable by the motor vehicle in at least three ways: (1) in response to rejecting a current location of the preceding vehicle as unreachable based on steering safety constraints; (2) in response to passing a previous current location of the preceding vehicle; and (3) in response to a new vehicle becoming the immediately preceding vehicle. In each instance, selecting the new most proximate destination

includes determining the preceding vehicle that is best reachable based on the current position of the vehicle during platooning (i.e., *an active position of the motor vehicle*), the current position of the steering wheel (i.e., *a steering properties...of the vehicle*), and the amount of steering change allowed at the current speed of the vehicle (i.e., *a capability of the vehicle*). See [11.1] analysis. The current location of the preceding vehicle that is best reachable is selected as the desired location for the vehicle. For instance, Broggi shows that when detecting a vehicle for platooning, a “search area” is searched in the same lane as the motor vehicle. See Ex. 1005, Fig. 18. In this way, Broggi determines the target as the next preceding vehicle in its current lane, i.e., the vehicle best reachable without requiring a change of lane. Further, Broggi estimates object distance as part of its operation (see Ex. 1005, 167) and may instead use the distance of a preceding vehicle to select one that is closest.

175. Thus, Broggi in view of Bertozzi renders obvious *the new most proximate destination* (the new current location of a preceding vehicle) *is selected based on an active position of the motor vehicle* (the current position of the vehicle during platooning) *and in determining the at least one accepted object that is best reachable considering a steering properties and a capability of the vehicle* (determining the preceding vehicle best reachable taking into consideration the current position of the steering wheel and permitted degree of steering wheel movement at the given speed of the vehicle).

[11.3] computing a new trajectory describing a new optimized travel path based on the active position.

176. Broggi discloses or at least renders obvious *computing a new trajectory* (new steering angle) *describing a new optimized travel path based on the active position* (a new desired path extends from the current position of the vehicle to the new current location of a preceding vehicle based on the new steering angle).

177. As described in the [11.0]-[11.2] analysis, Broggi in view of Bertozzi renders obvious *continuously monitoring a position of the stored at least one accepted object during the vehicle guidance and selecting a new most proximate destination [when] the most proximate destination is no longer easily reachable*. Broggi further discloses determining a desired path for the vehicle based on the new most proximate destination. Ex. 1005, Fig. 20-22. For example, Broggi discloses calculating a steering angle describing the new desired path between the current position of the vehicle during platooning and a new current location of a preceding vehicle.

178. During platooning, Broggi's motor vehicle continuously calculates a steering angle and corresponding desired path for each selected new current location of a preceding vehicle, as reflected in Figures 20 and 21, below:

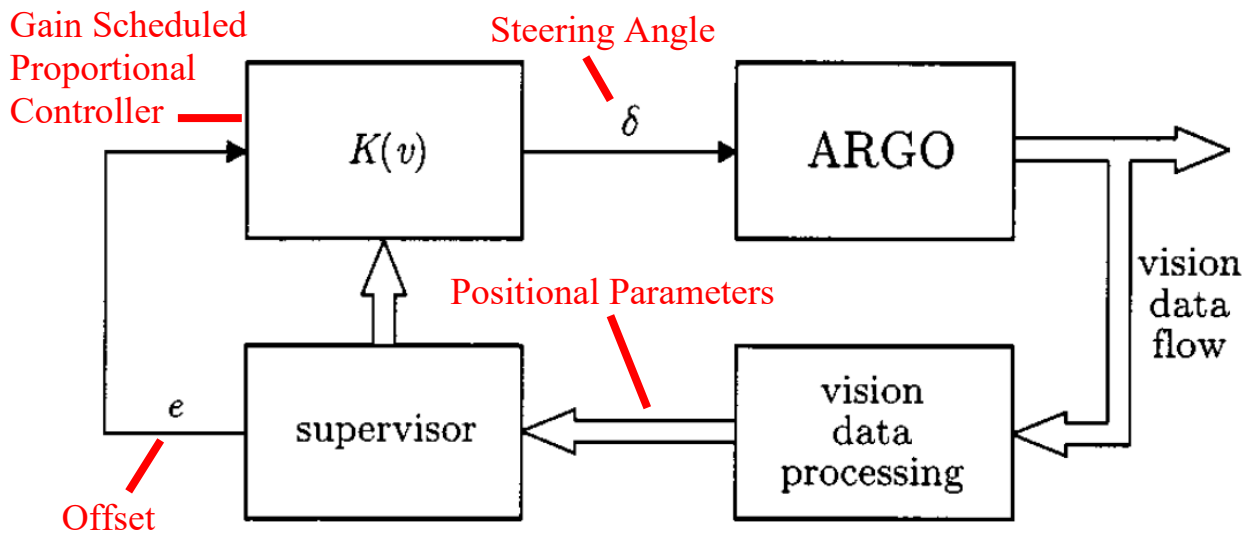
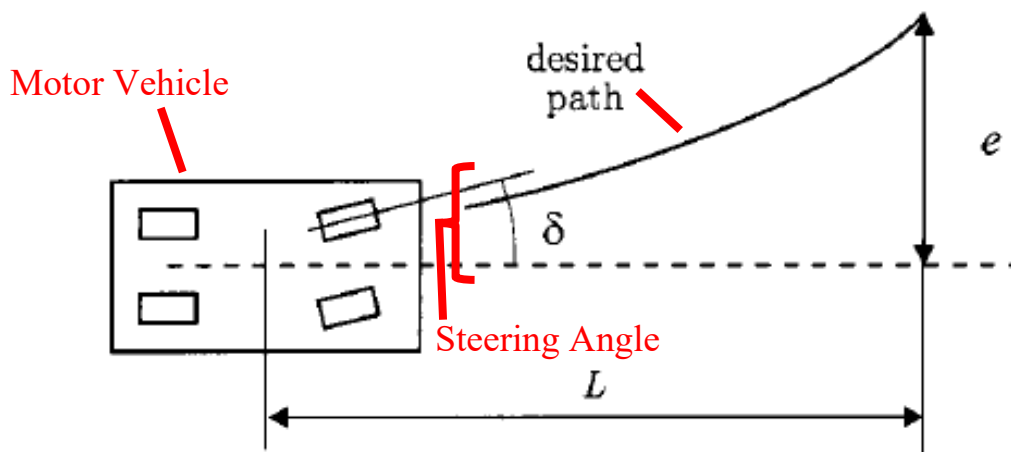


Fig. 20. Control scheme with the gain scheduled proportional controller.

Ex. 1005, Fig. 20 (annotated)



Ex.1005, Fig. 21 (annotated)

179. As discussed in Ground 1:[1.3], computing the steering angle and corresponding desired path in Broggi's platooning is *calculating a...trajectory*

describing a[n]...optimized travel path and is *based on the active position* of the motor vehicle because it is a trajectory from the current position of the vehicle. Accordingly, when the steering angle and corresponding desired path are calculated for the *new most proximate destination* (selected as discussed in the [11.1]-[11.2] analysis), Broggi is *calculating a new trajectory describing a new optimized travel path based on the active position* of the motor vehicle.

180. Thus, Broggi discloses or at least renders obvious *computing a new trajectory* (new steering angle) *describing a new optimized travel path based on the active position* (a new desired path extends from the current position of the vehicle to the new current location of a preceding vehicle based on the new steering angle).

XI. AVAILABILITY FOR CROSS-EXAMINATION

181. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross examination in the case and that cross examination will take place within the United States. If cross examination is required of me, I will appear for cross examination within the United States during the time allotted for cross examination.

XII. CONCLUSION

182. I hereby declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements are punishable by fine or imprisonment or both. *See* 18 U.S.C. § 1001.

Date: Jan. 3, 2025

Respectfully submitted,



Jeffrey J. Rodriguez