Create high-resolution adaptive headlights Using DLP technology

使用 DLP 技術創建高解析度自適應前照燈

以下原文源於 Texas Instruments

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11 月 20, 2018

Other Parts Discussed in Post: DLP5531-Q1

To achieve a glare-free high beam in a headlamp, designers can now turn to pixel-level digital control.

Traditionally, a typical automotive headlight beam only illuminates what's in front of a vehicle to improve visibility for drivers in low-light and poor weather conditions. Low beams illuminate the road a short distance in front of the vehicle, while high beams have a longer range and a wider angle. It's been that way for some time, but headlight systems are going through significant transformations thanks to new technological advances.

為了在前照燈中實現無眩光遠光燈，設計人員現在可以轉向像素級數字控制。

傳統上，典型的汽車前照燈光束僅照亮車輛前方的物體，以提高駕駛員在弱光和惡劣天氣條件下的能見度。 近光燈照亮車輛前方一小段距離的道路，而遠光燈則具有更長的射程和更廣的角度。 這種情況已經有一段時間了，但由於新技術的進步，前照燈系統正在經歷重大轉變。

Automakers began incorporating two sealed beams in the front of vehicles in the 1950s in the U.S., which eventually evolved to vehicles having both high-beam and low-beam options. Fast-forward to 2018, and vehicles are adopting more complex headlight systems. Light-emitting-diode (LED) sources are replacing the traditional halogen and xenon light bulbs. LEDs will likely completely replace xenon in the near term and halogen in the long term as automakers move from static incandescent bulbs toward dynamic and stylish LED illumination.

1950 年代，美國汽車製造商開始在車輛前部安裝兩個密閉式燈具，最終演變為具有遠光燈和近光燈兩種選擇的車輛。 快速前進到 2018 年，車輛正在採用更複雜的前照燈系統。 發光二極管 (LED) 光源正在取代傳統的滷素和氙氣燈泡。 隨著汽車製造商從靜態白熾燈泡轉向動態和時尚的 LED 照明，LED 可能在短期內完全取代氙氣，在長期內完全取代鹵素。

Unfortunately, despite decades of development, the U.S. National Highway Traffic Safety Administration (NHTSA) reported that approximately 30% of all accidents in 2015 occurred at night in the U.S. IHS Markit reported that 50% of all accidents in the U.S. are based on visual weaknesses; this number is bound to rise as the population ages.

不幸的是，儘管經過幾十年的發展，美國國家公路交通安全管理局（NHTSA）報告說，2015 年所有事故中約有 30%發生在美國夜間。IHS Markit 報告稱，美國 50%的事故都是基於視覺缺陷;隨著人口老齡化，這一數位必然會上升。

According to Germany's Technische Universität Darmstadt, in terms of visual performance, older drivers tend to experience a variety of types of vision degradation, including reduced visual acuity, age-related pupil reduction, and slower adaptation to the dark. Compared to 25-year-olds, those aged 60 to 65 need twice the illuminance and contrast and half the glare load to achieve a similar level of visual performance.

根據德國達姆施塔特工業大學的數據，在視覺表現方面，老年駕駛者往往會出現各種類型的視力下降，包括視力下降、與年齡有關的瞳孔

縮小以及對黑暗的適應較慢。 與 25 歲的人相比，60 至 65 歲的人需要兩倍的照度和對比度以及一半的眩光負荷才能達到相似水平的視覺表現。

Despite the fact that glare from high beams can be distracting or even cause temporary blindness, throughout the history of headlamps, preventing glare has always been left up to drivers, with a switch between high and low beams as the only control. As a result, drivers often spend their time with a finger on the headlight lever, toggling high beams on when alone on the road and turning high beams off when other cars appear on the horizon. But what if drivers could keep their high beams on while operating the vehicle to increase driver visibility?

儘管遠光燈的眩光可能會分散注意力甚至導致暫時失明，但縱觀前照燈的歷史，防止眩光始終由駕駛員決定，在遠光燈和近光燈之間切換是唯一的控制因素。因此，駕駛員經常將手指放在前大燈桿上，獨自在路上時打開遠光燈，並在其他汽車出現在地平線上時關閉遠光燈。但是，如果駕駛員可以在操作車輛時保持遠光燈打開以提高駕駛員的能見度呢？

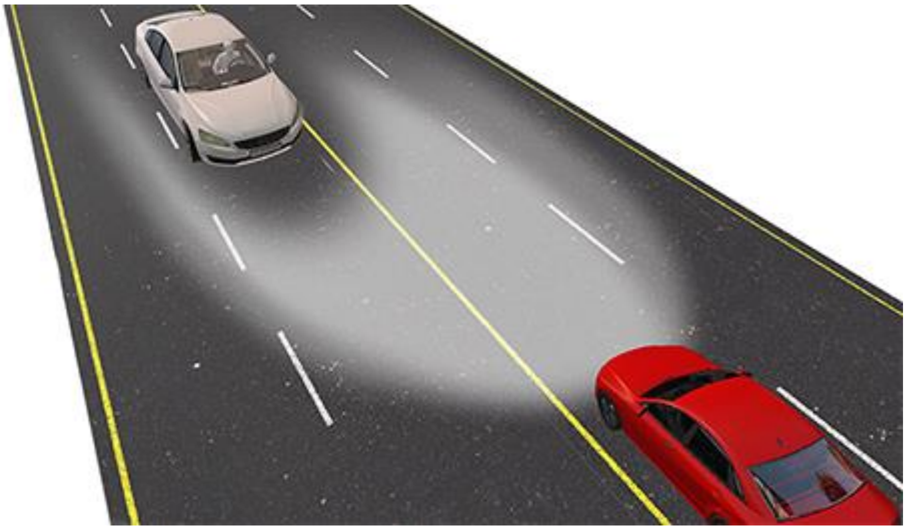

Figure 1: An example use case for adaptive-driving-beam (ADB) technology.

圖 1：自適應驅動光束 （ADB） 技術的示例。

This capability is made possible through adaptive-driving-beam (ADB) headlight technology (Fig. 1), which pairs advanced driver-assistance systems (ADAS) with exterior lighting systems. In addition to ADAS technology, Texas Instruments (TI) now offers a DLP chipset that can offer detailed control of a car's headlights through ADB technology, allowing automakers and Tier-1 suppliers to individually control more than 1 million pixels in each headlight. With this technology, headlights can black out areas that would otherwise blind other drivers or pedestrians, and can even be programmed to paint information on the road, such as lane lines or route guidance.

這種能力是通過自適應驅動光束 (ADB) 前照燈技術（圖 1）實現的，該技術將先進的駕駛員輔助系統 (ADAS) 與外部照明系統配對。 除了 ADAS 技術，德州儀器 (TI) 現在還提供 DLP 芯片組，該芯片組可以通過 ADB 技術對汽車的前照燈進行詳細控制，從而使汽車製造商和一級供應商能夠單獨控制每個前照燈中超過 100 萬個像素。 借助這項技術，前照燈可以遮蔽原本會使其他司機或行人失明的區域，甚至可以通過編程在道路上繪製信息，例如車道線或路線引導。

Micromirrors

At the core of every DLP chipset is an array of aluminum micromirrors known as digital micromirror devices (DMDs). Depending on the configuration, DMDs contain hundreds of thousands or millions of individually controlled micromirrors, with each micromirror being built on top of an underlying CMOS memory cell.

微鏡

每個 DLP 晶元組的核心都是一系列鋁製微鏡，稱為數位微鏡器件（DMD）。根據配置的不同，DMD 包含數十萬或數百萬個單獨控制的微鏡，每個微鏡都構建在底層 CMOS 存儲單元之上。

Each reflective mirror includes a flexible mechanical support structure that allows the mirror to be suspended over two address electrodes. These electrodes are connected to the memory cell and produce complementary electrostatic forces to position the mirror into one of two stable landed states.

每個反射鏡都包括一個靈活的機械支撐結構，允許反射鏡懸掛在兩個位址電極上。這些電極連接到存儲單元併產生互補的靜電力，將鏡子定位為兩種穩定的著陸狀態之一。

When integrated into an optical system, the DMD is a symmetric, bi-state, optomechanical element such that the position of each landed mirror determines the direction in which incoming light reflects. The high operating frequency and small pixel size of the DMD permits high-speed modulation and low system latency, which translates into more precise control of the light displayed on the road for automakers and enhanced driver visibility.

當集成到光學系統中時，DMD 是一個對稱的、雙態的光機械元件，使得每個落地鏡的位置決定了入射光的反射方向。DMD 的高工作頻率和小像素尺寸允許高速調製和低系統延遲，這轉化為汽車製造商更精確地控制道路上顯示的燈光並增強駕駛員的可見性。

DLP technology-enabled systems are capable of working with any light source, including LEDs and laser/phosphor and direct laser illumination sources, which can be designed to use less power and smaller, more stylish lenses than existing ADB solutions. DLP technology is also efficient and scalable, while providing greater control of light beams for improved observation distance and visibility in low-light conditions.

支援 DLP 技術的系統能夠與任何光源配合使用，包括 LED 和鐳射/螢光粉以及直接鐳射照明源，這些光源可以設計為比現有的 ADB 解決方案使用更少的功率和更小、更時尚的鏡頭。DLP 技術還具有高效性和可擴充性，同時提供對光束的更大控制，以改善低光照條件下的觀察距離和可見性。

Competing glare-free high-beam headlight solutions either dim individual LEDs in the lamp or shift the beam downward and sideways toward the opposing lane. Some solutions switch between high and low beams, while others rotate the beam as the vehicle turns. In effect, what these systems do is turn off or block the light displayed in their headlights to mask out oncoming or preceding vehicles to avoid glare. Typically, LED matrix-type solutions help reduce glare for oncoming drivers by turning off some of the LEDs.

與之競爭的無眩光遠光燈解決方案要麼調暗車燈中的單個 LED，要麼將光束向下和側向轉向對面車道。一些解決方案在遠光燈和近光燈之間切換，而其他解決方案則在車輛轉彎時旋轉光束。實際上，這些系統所做的是關閉或阻擋前大燈中顯示的燈光，以掩蓋迎面而來的或前方的車輛，以避免眩光。通常，LED 矩陣型解決方案通過關閉某些 LED 來幫助減少迎面而來的驅動器的眩光。

While basic auto on/off capability employing pre-defined discrete beam patterns are a step in the right direction, such capability doesn’t provide the level of control needed to develop beams with full, real-time adaptability. Such resolution and adaptability is attractive because it can enable ADAS functions such as traffic-sign illumination with traffic-sign recognition, which will be necessary in vehicles as the industry heads toward semi-autonomous and autonomous driving.

雖然採用預定義離散光束模式的基本自動開/關能力是朝著正確方向邁出的一步，但這種能力並不能提供開發具有完全、實時適應性的光束所需的控制水平。 這種分辨率和適應性很有吸引力，因為它可以實現 ADAS 功能，例如帶有交通標誌識別的交通標誌照明，這對於汽車行業走向半自動和自動駕駛是必不可少的。

Figure 2: ADB technology can be used to increase visibility on road signs.
圖 2：ADB 技術可用於提高道路標誌的能見度。

The advantage of TI DLP technology for high-resolution headlight systems includes reducing glare simultaneously on objects, such as pedestrians (Fig. 2), and drivers of oncoming vehicles. Minimizing the time from when the sensors deliver information to when the headlight reacts (system latency) achieves high accuracy by providing more pixels per degree of viewing angle. In turn, it enables more light throughput in the system and equates to more available light to control and display on the road. Low latency avoids the need for complex artificial-intelligence-based prediction algorithms to determine where an object will move next.

TI DLP 技術在高解析度前照燈系統方面的優勢包括同時減少物體（如行人（圖 2）和迎面而來的車輛駕駛員的眩光。通過在每個視角提供更多像素，最大限度地縮短從傳感器傳遞信息到前照燈做出反應（系統延遲）的時間，從而實現高精度。 反過來，它可以在系統中實現更多的光通量，並等同於在道路上控制和顯示更多可用的光。 低延遲避免了需要復雜的基於人工智能的預測算法來確定對象接下來將移動到哪裡。

A DLP-technology-based system uses additional sensor input to turn off the part of the headlight that would project onto the windshields of oncoming cars, causing glare discomfort or distraction for other drivers. By using DLP for headlight systems, very detailed control of the pixelated headlight beam is possible, enabling adaptive high-beam functions to help improve visibility and comfort during nighttime driving. Figure 3 shows an example of a system block diagram that includes the DLP chipset in a headlight system.

基於 DLP 技術的系統使用額外的感測器輸入來關閉前大燈一些部分，該部分是投射到迎面而來的汽車的擋風玻璃上，從而引起眩光不適或對其他駕駛員的分心的部分。通過 DLP 用於前照燈系統，可以對圖元化前照燈光束進行非常詳細的控制，從而實現自適應遠光燈功能，從而有助於提高夜間駕駛的能見度和舒適性。圖 3 顯示了一個系統框圖示例，該框圖包括前照燈系統中的 DLP 晶片組。

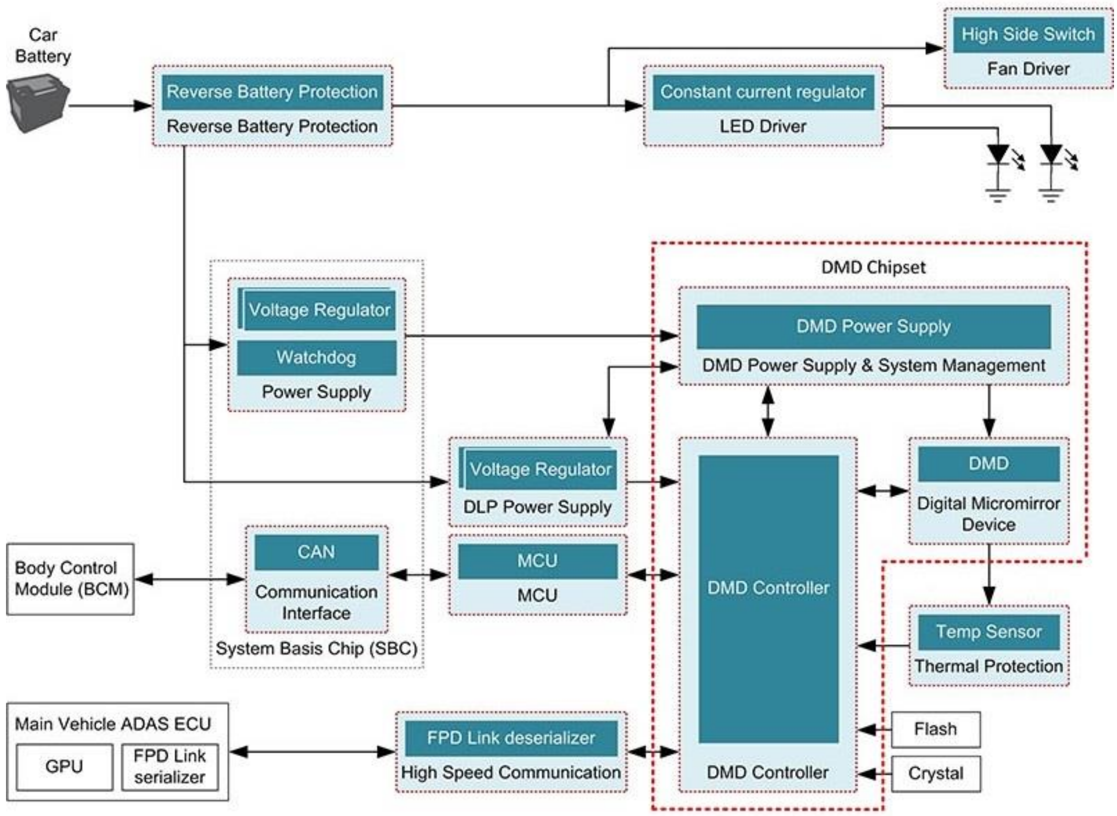

Figure 3: System block diagram featuring the DLP chipset.

圖 3：包含 DLP 晶片組的系統框圖。

The DLP5531-Q1 chipset for high-resolution headlight systems (Fig. 4) gives engineers a way to control light distribution on the road more precisely through customizable beam patterns in a smaller system form factor. The system also allows for partial or full dimming of individual pixels, potentially supporting consistent usage of high beams without impacting other drivers.

用於高解析度前照燈系統的 DLP5531-Q1 晶片組（圖 4）為工程師提供了一種通過更小系統外形的可定製光束模式更精確地控制道路上的光分佈的方法。該系統還允許對單個像素進行部分或完全調光，從而可能支援遠光燈的一致使用，而不會影響其他驅動器。

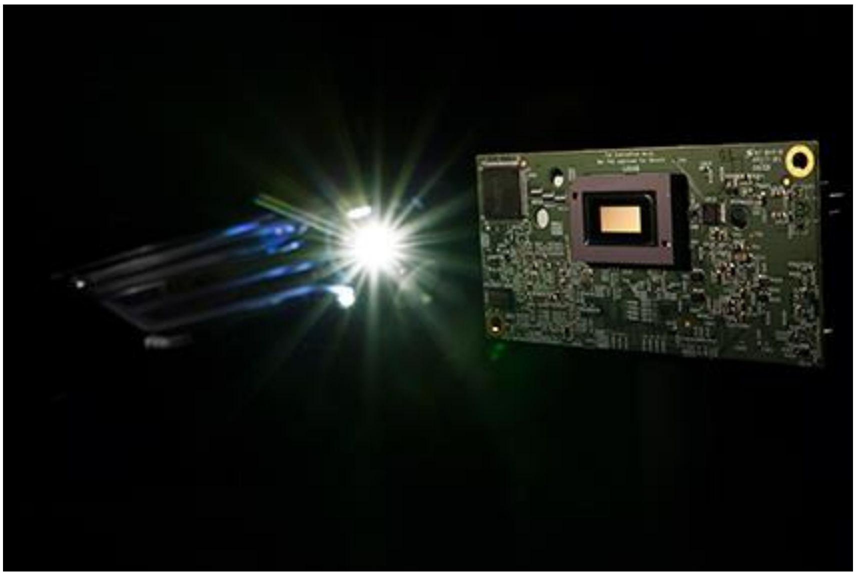

Figure 4: The TI DLP5531-Q1 chipset was developed by TI for high-resolution headlight systems.
圖 4：**TI DLP5531-Q1** 晶片組由 **TI** 開發，用於高解析度前照燈系統。

Future Uses of Headlight Tech

While many automakers and Tier-1 suppliers are focusing on the benefits of enhancing visibility, DLP technology is also programmable. As a result, it can be configured for the new functionality that will be required by semi-autonomous and autonomous vehicles.

前照燈技術的未來應用

雖然許多汽車製造商和一級供應商都專注於提高可見性的好處，但 DLP 技術也是可程式設計的。因此，它可以配置為半自動和自動駕駛汽車所需的新功能。

DLP technology for headlight systems can work with ADAS to project the right amount of light on specific spots, such as traffic signs, so that drivers can clearly identify the sign. Its ability to project images and signs onto the road ahead, such as lane markings or navigation directions, will enhance communication between drivers, pedestrians, and other vehicles, a feature that will become more important as the industry moves forward.

用於前照燈系統的 DLP 技術可以與 ADAS 配合使用，將適量的光線投射到特定點，例如交通標誌，以便駕駛員可以清楚地識別標誌。它能夠將圖像和標誌投射到前方道路上，例如車道標記或導航方向，這將增強駕駛員，行人和其他車輛之間的通信，隨著行業的發展，這一功能將變得越來越重要。

Headlight systems using this technology can be programmed to enhance car-to-pedestrian communication by providing signaling or signs to pedestrians and indicating what the vehicle will do next. In addition, dedicated lane marking and enhanced car-to-driver functions like symbol projection and the display of relevant information for drivers (e.g., navigation support, vehicle trajectory) are important considerations for future vehicles.

使用該技術的前照燈系統可以程式設計，通過向行人提供信號或標誌並指示車輛下一步將要做什麼來增強車對行人的通信。此外，專用車道標記和增強的車對駕駛員功能，如符號投影和駕駛員相關信息的顯示（例如，導航支援，車輛軌跡）是未來車輛的重要考慮因素。

Additional Specs

The DLP5531-Q1 chipset supports more than 1 million addressable pixels per headlight. Working with any light source (including LED and laser), it operates between -40°C and 105°C, enabling clear image visibility regardless of temperature or polarization.

其他規格

DLP5531-Q1 晶元組支援每個前大燈超過 100 萬個可尋址圖元。可與任何光源（包括 LED 和鐳射）配合使用，其工作溫度範圍為 -40°C 至 105°C，無論溫度或偏振如何，都能實現清晰的圖像可見性。