

Digit and the Moon Shadow

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“Wow,” I mumble half to myself, “Monday morning seems to be a lot earlier than usual today.” There was a party at my friend’s house last night and I am really groggy this morning.

The clock says it’s 7:30 already; I’ve got to get moving – I can’t be late the first day of class!

I shower, dress, and get ready to meet the day in 23 minutes flat. That’s a new personal best, I think, smiling to myself. I wave goodbye to Dad, who seems to be permanently hunched over the computer lately. I grab my backpack and head for the door.

“Hey! Have a look at this before you go,” he says, handing me the newspaper. The headline reads: Golden Dragon Stolen. “It’s my case, if I want it. What do you think – want to go on a dragon hunt?” he says with a big grin.

“Golden ones, yes; go after the real ones and you’re on your own,” I tease. “I’m late – see ya later, Dad.”

After my last morning class I head over to the Dog House for lunch. I pick up a newspaper at the corner stand to see what this dragon thing is all about. Just below the fold, it says:

“A solid gold, two-headed dragon was stolen from the lobby of Gemini Bank’s twin tower headquarters last night. Mr. Ken Tong, Chief of Security for the bank said, ‘It’s still under investigation. We are not sure how the thieves got in, or how they got away with that heavy statue. The alarm didn’t trigger. We’re going over the surveillance tapes now.’ The statue was valued at \$12 million, Tong said.”

The article goes on to say that the theft took place that night, by the light of a full Moon in a cloudless sky. My father is a private investigator who handles insurance fraud cases, and I think he's going to have a good time with this one. Twelve million dollars – too bad he doesn't get a recovery fee!

My math class this semester is Trigonometry, or *trig* for short, and it looks like it's going to be a lot of fun. Trig deals with the relationships between the angles and the sides of triangles. That sounds pretty dry, but in the first chapter it says that a Greek mathematician named Eratosthenes determined the circumference of the earth using trigonometry back in 200 BC. "So that's where Columbus got his confidence," I muse. It also says that trig can be used to measure the distance to the Sun and to some other stars. There is a CD-ROM in the back of the book with a lot of cool sounding software on it. I'll have a closer look at that when I get home tonight.

Over supper I tell Dad about my trig class. He seems only mildly interested until I mention the CD; he suggests that we have a look at it. I pull out my book and drop the CD into the desktop's drive tray. After a minute or so the introduction begins: Swirling galaxies become stars and then planets around a star; closer now, we see satellites around planet Earth, ships on its oceans, and highways connecting its cities. Still closer, we see skyscrapers among the smaller buildings, and head right into the bricks for a look at their atomic structure – tiny nuclei encircled by electrons. Strangely reminiscent of planets around a star, I think. A melodic female voiceover confirms the similarities I see and gives an overview of what's on the CD. Dad clicks the *Applications* button and we're off on another animated journey.

Two lighthouse keepers, separated by a few miles, the voice says, can determine the distance to a ship on the horizon by *triangulation*, using their two compass bearings. (That reminds me about how weather spotters take compass reading off lightning flashes to triangulate the position of a storm cell.) The CD goes on to say that *parallax* can be used to find the distance to the closest stars. The two angular readings in this case are taken from opposite points in Earth's orbit! Most of the stars that we can see, it says, are too far away to detect any parallax, even when we employ that great a separation distance, but astronomers have other methods they can use in those cases.

This is kind of cool. I don't know that I care how far away Vega is, but I'm wondering if we can use parallax to find out how high a model rocket goes. Back on the Applications menu I notice *Ray Tracing* and ask Dad to check that one out.

Ray tracing, it says, is used to design optical systems, like telescopes. It is also used by animation software developers to add highlights, realistic reflections and shadows to computer games. Now they've got my attention; this definitely warrants a closer look!

"Well that's pretty interesting," Dad says, handing me back the CD. "And I'll bet you'll eat this trig stuff up, won't you," he adds, smiling at me. Dad seems to think I'm really smart, but I sure don't feel that way. I could barely grasp what we talked about in today's class. I'm going to have to reread that whole section again tonight before I can do the homework.

"Any luck finding your dragon?" I ask.

"Not yet," he replies. "The thieves got in and out without setting off the alarm. Scratches on the floor suggest they went through a big plate glass window, but the window is intact and there is nothing on the surveillance tapes. They probably wore gloves because there isn't a fingerprint anywhere, either. We're at a loss; no pun intended," he adds smiling.

"Well I better get started on my homework." I grab my backpack and head for my room. When I get there, however, I can't resist having another look at that ray tracing demo on the CD...

A few nights later we get a call from Frank, Dad's old partner, back when he was on the Chicago Police Force. (Dad left the Force when Mom died.) "Hey, Frank. What's up?" Dad asks. From what little I hear of their conversation, it sounds like he's on that bank robbery case and wants to meet with Dad.

"Frank is heading up my dragon hunt," Dad confirms, "and wants to meet for coffee."

“Can I come along?” I ask.

“This’ll be pretty much chitchat. They don’t have a lot to go on at this point in the investigation.”

“I finished my homework and I’d rather not sit home alone tonight,” I plead.

“Okay,” Dad says. “Come on along.”

We get to the restaurant and see Frank’s *unmarked* car. (Every kid I know can spot them a block away.) Frank is already half way through a piece of pie. “Sorry,” he says rising to shake hands with Dad. “I haven’t had anything to eat since lunch.”

“You need to get married and settle down, Frank,” Dad kids him. “You’re spending too much time at the Station.”

“Yea, well,” Frank admits, smiling. “This case is getting hot. Benny Benjamin, President of Gemini Bank, is golfing buddies with the Mayor and several City Councilmen. And he was Aldermen of the 44th Ward a few years ago.”

“So the game’s afoot, huh?” Dad says.

“Yep, and I’m being very careful where I put my toes,” Frank adds.

“The security people at the bank found nothing,” Frank says, shaking his head. “Benjamin lives across the street in a penthouse apartment overlooking the headquarters building and its lobby. He has a pair of cameras mounted on his balcony. Both cameras were working fine all night, but there was nothing unusual on either tape.”

Frank's cell phone rings and he flips it open for a short conversation. "We just put in a new AV Lab at 11th and State," Frank says, closing his phone. "The tapes just got there. Want to go have a look?"

"Sure," Dad says. I think I might have objected had he said anything else – an Audio-Video Lab at Police Headquarters – man, would I like to see that! We pile into Frank's car and head south.

We turn east on Fullerton, on into Lincoln Park, and head south again along the lake front. Lake Shore Drive, or the *Outer Drive*, as the locals call it, is a relic by modern highway standards, but it's one of the most beautiful drives in the United States. All the beaches fly past our window; the pedestrian overpass and the boat house at North Avenue beach come into view. In the distance, I see Lake Point Towers on the tip of a land mass that juts out into the lake – what must it be like to live there, I wonder. Off the Drive, now, we continue south along Michigan Avenue, with all its lights and expensive stores: Chicago's Gold Coast. A quick right turn and then a left, and we dip down into the underground garage at the Chicago Police Department's headquarters building. We head up the elevator to the sixth floor, where Frank shows his badge to the desk sergeant. Dad and I put on ID tags and we file down a narrow hallway toward a small sign on the ceiling that says simply, AV Lab.

"Hi, Bob," Frank says to the technician. "This is my old partner and his daughter, Digit."

"Digit – really?" he asks with a friendly smile.

"Not exactly," I explain, "My name is Bridgett – Digit's a nickname."

"She's a math and computer wiz, so you better watch what you say around her," Frank says. "Did the bank tapes get here yet?"

“Yes, and I just loaded them both for synchronized playback,” Bob says, as he hits the Play button. “Don’t expect to see much. What we have here is a moving picture of a stationary building, ala Andy Warhol!”

And he’s right: absolutely nothing is happening, and he’s running it at about 60x real time. “What was that,” I ask, noticing something.

“What was what,” he echoes, stopping the tapes and running them backwards.

“There,” I say, “the image seems to get dimmer.” He stops it again and runs it forward, slowly this time. Sure enough, there is something there. The building gets dark for just an instant.

“It looks like a shadow,” Bob says, running it back in slow motion. “Yes,” he confirms, “it’s probably an airplane’s shadow in the moonlight.”

Before he starts it all up again, I add, “Something still looks funny. Can we take a closer look?”

“Okay,” Bob says. Frank and Dad are leaning toward the screens and squinting at the images.

“There,” I say. “That moon shadow should be going across the face of the building, shouldn’t it? It looks like it’s coming in from both sides at once and disappearing somewhere between the two towers,” I explain. “That’s odd.”

“You’re right,” Bob agrees. He runs through it several more times, writing down tape position counter values. “Thanks!” he adds. “I’m glad you spotted that. It’s easy to glaze over watching this sort of stuff, and I could have spent several more hours before noticing something like that.” Frank asks Bob to print out a still image of the shadows that clearly shows the anomaly and takes Dad with him down the hall.

“So you’re a wiz kid, huh,” Bob asks, making conversation.

“Not exactly,” I explain, “but I am really interested in computers, and I won a scholarship at the Math Fair last year,” I brag a little.

“That’s terrific,” Bob say, “My Bachelor’s degree is in Math and Computer Science – I just graduated from the U of I.”

“That’s the program I want to get into – Circle or downstate,” I ask.

“Circle,” he says. “I didn’t want to go away to school. I got the job as an intern with the Police Department right out of high school. I worked full-time in summer, and part-time on nights and weekends when school was in session. They paid for my tuition and my books, and I get to play with these cool toys all day,” he added smiling. “What are you interested in?”

“I am taking trig,” I tell him. “We’re learning about triangulation and parallax, and I’m looking into ray tracing on my own. My book came with a CD that has a ray tracing software package and it’s really neat stuff.”

“Then you’re really going to like this,” Bob says, handing me a CD. “It’s a 3D model of Gemini Bank’s twin tower headquarters and the apartment complex across the street, including the pair of video cameras mounted outside the penthouse apartment – have some fun with it.”

“Wow – thanks! I certainly will,” I promise. I hear Dad and Frank coming back down the hallway and I slip the CD into my coat pocket. After Frank explains to Bob what the Robbery detectives are going to do, we all head back down the elevator to the garage. Frank drives us back to the restaurant for some more pie and coffee. Dad and I head home after that – what a night!

The next day I buy another newspaper to read before class. There is a more detailed article on the robbery, but it's made its way back to page ten already; the public has a short attention span, I guess. It says a Mr. Ben Benjamin (his full name is actually Benjamin Benjamin, believe it or not), the President of Gemini Bank, had the twin towers of the main branch built across the street from an apartment complex, which he also happens to own. He had a pair video cameras (he would have two cameras!) installed as an extra measure of security. The two-headed dragon was his idea, as well. It's the bank's mascot and logo, a registered trademark of the Gemini Bank.

The story goes on to say that Benjamin had an identical twin who died in childbirth, and that he didn't know about it until his late teens, when he happened to overhear a thoughtless comment from a relative at a family gathering.

He was devastated, at first, angry at not knowing about it all this time, and confused as to why he survived and his *other self* didn't. He came to grips with the situation, eventually, but he became obsessed with the sense of having to live his life for both of them. His controlled anger became a drive that got him through Harvard business school near the top of his class, and helped him build his bank into one of the few remaining successful independents in the Midwestern United States.

His wife is much younger than he is, and doesn't like sitting at home while he puts in his usual 80-hour week. She's quite the society girl and celebrity about town. She hosts charity fund raisers and is usually in the front lines when new a city building is dedicated. She was given the honor of christening the Mayor's yacht, the *Windy*, last year in a big ceremony near the Adler Planetarium. They even brought out the Police and Fire Department boats for that one; their sirens blared while they shot red, white and blue water spouts high into the air. My kind of town, Chicago is...

I finished all my homework at school during Study Hall so I could start up that 3D model as soon as I got home. Really cool controls let me view the scene from any angle, even from below street level! In the very back of my mind, however, I couldn't help wondering what that shadow on the surveillance tapes was all about.

I continued fiddling with the model when a flash of insight hit me: “They did it with mirrors!” That was the thought that popped into my head, anyway, and it stopped me cold – in mid-fiddle, you might say. Was this a joke that my mind was playing on me? Could it actually be done with mirrors? Well, yes, I guess it could. My thoughts turned back to the ray tracing software package. I removed the model CD and replaced it with the one from my trig book.

I established a point-of-view, or POV in ray tracing parlance, and constructed a pair of right triangles with their hypotenuses facing each other, so to speak, making it obvious to the viewer which was on the left and which was on the right. In the foreground I added a reflective surface and started rotating it in every direction I could think of. No way was I going to get that right triangle in line with, and in front of the left one. I sat back to think about this for a while.

I added a second mirror, and then a third. Combining them in just the right way, I thought for a moment that I could get this to work, but I was starting to get confused. I filled the right triangle with a red color, and the left triangle with blue. I started fiddling with the mirrors again – there!

Using the mouse pad on my laptop, I set the three mirrors in front of the POV and lo and behold, there were two red triangles, facing one another. I had managed to build an optical system that would reverse the bank building’s right tower and line it up with the left tower! I saved the ray tracing model and burned it onto a blank CD-ROM. “Wait till Bob sees this,” I thought.

The next day, right after my last class, I took the bus downtown to 11th and State. I went inside and asked to see Bob in the AV Lab. The desk sergeant called him, told him my name, and I waited until he came down. I clipped on an ID tag and Bob escorted me up into the Lab.

“Bob,” I said as we entered the Lab, “This time I have a CD for you. It’s a point-of-view model that I made with that ray tracing software I told you about. If my idea is correct, there must be something else on those tapes that we missed. Can we have another look?”

“Sure,” he said. “They’re still up.” He set them both up in time-synch mode and fast-forwarded them to the shadow. I asked him to start the tapes going backward from that point.

After several minutes we got to the point where it was getting light, just after sunset. We could see the last person leave the bank and the security guard locking up for the night. “Okay,” I said, “start them going forward again, but very slowly.” Several more minutes went by that seemed to take an hour. I could see the counters getting closer to the point where the shadow appears, but then I saw what I was looking for. “There,” I shouted. Bob stopped the tapes and started them going backward again.

“Look at that,” I say pointing.

“It looks like the video image lost sync for a brief moment,” Bob said. “That’s just a sync line moving up the screen.”

“Oh no, it’s not. I think that’s the top edge of a mirror! Have a look at this,” I say, handing him my CD. Bob drops it into the tray and starts up my ray tracing model.

“Cool,” Bob says, seeing what I made. He instinctively starts moving the mouse, anticipating how it all works, and actually gets the set of mirrors into the right position without any help from me.

“I’m impressed,” I say. “That’s what I came here to show you. I think someone prefabricated a framework of mirrors and slid them into place from the balcony of the apartment downstairs.”

“Now I’m impressed. Wait here,” Bob says, and heads down the hallway.

“Digit,” Bob says, returning with an older man, “This is Detective Bell, from Robbery. Show him what you’ve got here.” Bob reruns the part of the tape where the line comes up from the bottom edge. I show him my ray tracing model of the scene and explain how someone could have used a

set of mirrors to replace the video image of the left tower with a reflected image of the right tower. If that's what happened, nothing inside the left tower's lobby would be recorded, yet the surveillance tapes would appear normal!

"Now that's a good one," Detective Bell says. He flips open his cell phone and makes a quick call. "I'm going to get with my partner and follow up on this – nice catch, you two!" Bob helped me a lot, so I didn't mind sharing the credit with him.

I got in just a little later than I would have walking home from school, and just in time to hear Dad on the phone saying "She's just coming in now." After he hung up he said Frank had quite a story to tell. We both sat down at the kitchen counter. I got out my laptop and went through the whole demonstration again. Dad didn't say anything, but he did let out a low whistle, and I know exactly what that means.

A few days later Dad had an open newspaper ready for me when I came home from school, and added that Frank filled him in on some of the unpublished details: Apparently, Benjamin's wife was having an affair with the doorman in the apartment building. He had a long history of petty theft, graduated to breaking and entering, and did a short stretch in prison for his part in a jewelry store robbery. The wife overheard Benjamin complaining to his security chief at the bank's Grand Opening ceremony: it seems that one of their large plate glass windows wasn't properly wired into the alarm system. That problem never did get corrected, and she told her boyfriend about it. Together they hatched this scheme to steal the golden statue, fence it, and run off together.

One of the maids, however, spotted the doorman entering the apartment below the penthouse. She mentioned it to the police during the original questioning, but nobody thought it was important. "That is, until you poked your bright little nose into it," Dad added, smiling at me.

"They recovered the statue, unscathed, inside a stolen moving van that was parked behind the apartment building, where nobody thought it looked out of place. The doorman's prints were all over the van, the statue, and a very cleverly designed framework that held three front-surfaced

mirrors!” Dad added. There was genuine pride in his eyes and I realized again, just how lucky I was to have such a great father.

The phone rings and Dad picks it up. “Hello,” he says. Then he looks up and says to me, “Frank wants to know if we can come down to the Station. He says we should dress nice, but he won’t say why.” I nod, and he says into the phone, “Sure, we’ll be there in half an hour,” and hangs up.

Dad puts on a tie and grabs a sports jacket, and I wear a dress and my new shoes. When we get to the Station house, there are reporters on the steps. We push our way through them and into the lobby. Frank is there, as is Detective Bell and another policeman, a TV camera crew, and the Mayor himself! Seeing us, he steps up to the podium. They turn on the cameras and he makes a short speech about how everyone seemed to be interested in Math and Science during the Space Race, when he was in high school, and how that interest seems to have waned these days. He motions me up beside him and says, “How fortunate it was for the Gemini Bank and the City of Chicago that this young lady still believes such skills to be important.” I blush as he hands me a Chicago Police Department Certificate of Appreciation. The TV cameras are still rolling as Mr. Benjamin steps up to congratulate me, too, and they zoom in on us as he hands me a small, gold statue of a two-headed dragon!”